NOVEMBER, 1958
Vol. 12, No. 11

# FT food technology

## New Varieties for Frozen Foods

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IN THIS ISSUE—

# THE TECHNICAL ARTICLES IN BRIEF

*Sanitation engineering* *Processing citrus concentrates*

**Sanitary control in processing citrus concentrates. I.** Some specific sources of microbial contamination from fruit bins to extractions. D. I. Murdock and Charles H. Brokaw.

Each fruit handling operation was investigated to determine its effect on fruit surface contamination. It was found that fruit is recontaminated by bins and flight elevators. The brush washer and chlorinated water rinses effectively reduced fruit surface contamination. The result of these sanitizing operations is minimized, however, if subsequent fruit handling equipment is not kept in a sanitary condition. Slimy fruit sizers, conveyor belts, especially those in the juice room, are all contributing factors. Each unit operation of the fruit handling system must be carefully watched to prevent contamination of extracted juice. Importance of an efficient fruit grading system is discussed. Data are presented to show correlation between fruit quality and microbial load of extracted juice. (See page 573).

*Retarding oxidation* *Light-screening agent*

**Use of a light-screening agent for retarding oxidation of process cheese.** B. E. Ellickson and V. Hasenzahl.

Occurrence of off-flavors known as "oxidized flavor" due to light exposure of cheese has been known to the cheese industry for some time. This paper reports a method of retarding this oxidation while process cheese is on display in dairy cases illuminated by fluorescent lights. Retardation is accomplished by incorporating a light-screening chemical, a substituted benzophenone, in the wax coating on process cheese wrappers. The photochemical action of light in the ultraviolet range is slowed from the usual 12-hour period to 64 hours. Influence of color in the cheese wrappers is also discussed. (See page 577).

*Bulk transportation* *Citrus juices*

**Technological considerations in the bulk transportation of citrus juices.** David O. Hamrick.

Technological considerations in transporting bulk citrus juice from a Florida citrus processing plant to a New York City bottling and packaging plant are presented. The citrus juices are transported in large (30,000 to 70,000 gallons each), insulated, stainless steel tanks aboard a steamship. Loading and unloading is accomplished by pumping procedures. Feasibility studies preceded the actual construction of the plants and basic research was performed in anticipation of many unique problems in such an unorthodox method of handling and transporting this perishable product. Problems and solutions discussed include the cleaning and sanitation of the tanks, pumps, pipelines, and related juice handling equipment; microbiological control before, during, and after transportation; temperature control and regulation; and control of other product deteriorating factors such as aeration, foaming, pulp seperation, temperature stratification, etc. (See page 579).

*Radiation preservation* *Antibiotic-treated meats*

**Effect of irradiation on antibiotic treated meats.** R. F. Cain, A. W. Anderson and A. S. Malaspina.

Antibiotics (tetracycline hydrochloride, oxytetracycline, chlortetracycline, oleandomycin, tetracycline, neomycin and polymixin) were incorporated in ground meat and water and radiated at levels of 0.18, 2.79 and 5.58 megarad. Additional samples of the first 3 antibiotics were radiated at 0.18, 0.37, 0.74, 1.48, 2.79 and 4.65 megarad. The residual antibiotic activity and the protective effect of the meat are reported. Oxytetracycline was injected into the hogs before slaughter. Portions of the loin, butt, and pienic were further radiated at 0.79 megarad and samples stored at 50° F. These samples were analyzed for their storage characteristics. Oxytetracycline solution of 100 p.p.m. was used as a dip for slices of beef. Slices were dipped and drained for controlled periods and then film packaged. Radiation was carried out at 0.1 and 0.3 megarad. Total numbers of organisms, residual antibiotic and flavor were determined during the storage period at 34° F. (See page 582).

*Protein supplement* *Defatted wheat germ*

**Improvement of cereals with defatted wheat germ.** N. T. Rand and V. K. Collins.

Wheat germ protein has the high biological value of animal proteins as measured by the Mitchell paired feeding method. This was confirmed by a modification of the Hinners-Scott chick growth assay. This assay was used to measure the nutritive value of cereals and cereals supplemented wtih defatted wheat germ. Steaming and light toasting did not impair the nutritive value of the defatted wheat germ. Unexpectedly, the nutritive value was apparently increased. As single cereals the nutritive values of oats, barley, rice and enriched wheat flour were found to be in a decreasing order. Ten per cent levels of toasted defatted wheat germ improved the nutritive value of cereals as follows:

**NOVEMBER COVER.** Varietal differences in plant products are reflected in quality differences. The November cover shows horticultural workers studying new varieties of snap beans to find those best suited for freezing. Photograph by courtesy of Birds Eye Division, General Foods, Corporation, White Plains, New York.

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Supplemented cereals with toasted wheat germ considerably enhanced their nutritive value and their palatability. (See page 585).

*Antioxidant treatment* *Paperboard*

**Antioxidant treatment of paperboard for increased shelf life of packaged dry cereals.** E. F. Caldwell and Sylvia Shmigelsky.

Double-bleached manila-lined chipboard was treated by the board manufacturer with butylated hydroxyanisole prior to being made into one-ounce individual cereal packages. The antioxidant was applied to inside surface of the board in an amount equal to 0.05% of the board by weight. Three types of flaked dry cereal were packaged in this material, each package being overwrapped with 300 MST Cellophane. Shelf life tests were conducted at room temperature and at 100° F. Control packages of board were prepared and included in these tests. Panel evaluations of aroma, flavor and over-all preference were conducted after 18 weeks and 52 weeks with groups of about 35 non-expert judges using the hedonic rating system. Antioxidant treatment of the paperboard was found to result in a significant improvement in acceptability after storage in all 3 cereals. (See page 589).

*New instrument* *Nondestructive measurement of fruit maturity*

**An instrument using light transmittance for nondestructive measurement of fruit maturity.** G. S. Birth and K. H. Norris.

An instrument is described which indicates stage of maturation of certain agricultural products. Criterion for indicating stage of maturation is the wavelength of the first transmittance peak when scanning from 500 mμ to 700 mμ. Instrument consists of a small monochromator which uses an inexpensive wedge interference filter for the dispersion. The filter, driven by an electric motor, provides the monochromator with a continuous scanning region from 400 mμ to 700 mμ. A multiplier type phototube is used for measuring the transmitted light. In operation, the whole fruit is placed inside an integrating sphere in such a manner that the light must be transmitted through the fruit to reach the phototube. The wavelength-scanning motor is started manually and an electronic control circuit stops the scanning motor automatically when the light transmitted through the sample reaches a maximum. Data are included to show the change in this measurement vs. time for a few samples of fruit. (See page 591).

*Measurement* *Maturity of plums*

**Evaluation of light transmittance techniques for maturity measurements of two varieties of prune-type plums.** Jane V. Ernest, G. S. Birth, A. P. Sidwell and C. Golumbic.

An electronic device specially designed to indicate the wavelength of peak transmittance of intact fruit was tested for performance in indicating changes due to maturation on the tree and post-harvest ripening in storage. Plums were the varieties Stanley and Fellenberg. Samples were harvested at 5- to 7-day intervals beginning 30 and and 40 days before full maturation of the respective varieties. Portions of these samples were tested immediately after harvest, the remainders were stored at 55° F. and tested at 2- to 3-day intervals until the fruit was as ripe as its stage of harvest maturation would permit. In addition to readings of wavelength of peak transmittance, determination of established maturity indices such as soluble solids, titratable acidity, firmness, and Hunter's "a" were made. The last two determinations were made on the Maryland Shear Press and the Gardner Color Difference Meter, respectively. Cut, de-stoned fruit was used for both measurements. Wavelength readings were found to increase from ca. 545 mμ to ca. 640 mμ during maturation of the fruit on the trees. Readings of fruit undergoing post-harvest ripening in storage increased similarly, with the exception that early harvested fruit did not reach as high level of readings as late. Wavelength of peak transmittance appeared to be related closely to Hunter's "a", both in respect to changes during fruit maturation as well as those occurring during post-harvest ripening. This is to be expected, since the "a" filter-phototube combination is sensitive in the 550-650 mμ region, while combinations for atttributes "L" and "b" are relatively insensitive in that region. A very high linear correlation between wavelength of peak transmittance and soluble solids was also observed. Loss in firmness as measured by shear resistance correlated highly with wavelength readings especially on tree-maturing fruit samples. (See page 595).

*Antioxidant treatment* *English walnuts*

**Effect of moisture and antioxidant treatment on shelled English walnuts.** D. M. Swarthout, R. A. Johnson and S. de Witte.

Absorption of oxygen from the headspace air in sealed cans containing shelled walnuts was used to compare the efficiency of two antioxidant fromulations: (a) butylated hydroxyanisole and butylated hydroxytoluene and (b) butylated hydroxyanisole, propyl gallate, citric acid, propylene gallate, and mono- and di-glycerides. Absorption was also used to compare shelled walnuts treated with antioxidants against untreated walnuts. This gave a measure by which their effectiveness to retard oxidative rancidity could be evaluated. The effect of various moisture levels on kernel storage life was determined by measuring the free fatty acid concentration. BHA and BHT, in vegetable oil, when applied to shelled walnuts reduced the oxygen absorbed by approximately two-thirds. The BHA-PG formulation reduced the oxygen absorbed by approximately one-half. Oxygen absorption increases as moisture content increases. In general, the rate of free fatty acid formation also increased as moisture increased, and was not affected by either antioxidant formulation. (See page 599).

*Engineering* *Jacketed freezer*

**Studies on a jacketed cold-storage room.** Joseph W. Slavin, John A. Peters, and S. R. Pottinger.

Tests were carried out to determine the effect of engineering design on the operation of a jacketed freezer and on the relative keeping quality of fishery products

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stored in a jacketed freezer and in conventional freezers. Engineering tests were concerned with effect of jacket fan speeds and/or room-temperature fluctuations on jacket air flow, jacket duct and air temperatures, relative humidity of storage room, and equipment electrical energy requirements. Effect of various jacket fan speeds on "freezer recovery" time due to air infiltration caused by personnel usage was also studied. Results show relative humidities of 92 to 95% can be obtained at comparatively low rates of jacket air flow, provided storage room temperatures are kept within $\pm 0.5°$ F. Larger temperature fluctuations of $\pm 2.5°$ F. decrease room relative humidity and necessitate increased rates of jacket air flow to accomplish the required refrigeration effect. Equipment electrical energy requirements vary with room temperature and jacket air flow and are estimated to be 20–22% higher than those of a conventional type freezer under optimum operating conditions. Recovery time due to personnel usage increases with reduction in jacket air flow. In the application of a jacketed cold-storage room, every effort should be made to keep load conditions as constant as possible in order to maintain a high relative humidity, low rate of jacket air flow, and low cost of operating the equipment. Frozen-storage tests also were conducted to determine comparative keeping quality of samples of shrimp, haddock fillet blocks, haddock fish sticks, and albacore tuna stored at a high relative humidity in the jacketed freezer and in conventional cold-storage rooms using overhead plate or finned-pipe-coil evaporators. Results show samples stored in a jacketed freezer undergo considerably less dehydration, as evidenced by weight measurements, than do similar samples stored in a conventional cold-storage room. The taste-panel could not find significant differences in quality of cooked samples, however, as determined by flavor, odor, appearance, and texture that could be attributed to method of storage employed. (See page 602).

*New product* *Low-moisture pitted cherries*

**Low-moisture red sour pitted cherries.** M. J. Powers, N. J. Downes, D. W. Sanshuck, and L. H. Walker.

Low-moisture red sour pitted cherry pie stock was prepared from frozen red sour pitted Montmorency cherries. Fresh pitted cherries were treated, frozen on trays, and stored at $-10°$ F. They appear to be stable for long periods while in the frozen condition. The frozen cherries were dried directly *in vacuo* on trays held at 140° F. No heat damage, no significant losses of flavor, and no losses of product occurred. The weight of the product is 15% of that of the fresh pitted material. In the dry condition it had a dark natural red color and was only slightly collapsed in appearance. Data are presented on stabilizing additives, freezing, drying, and packaging methods, storage stability, and organoleptic evaluation. This low-density pie stock had unusual stability. When stored for 6 months at 100° F., it was rehydrated readily and baked into a highly acceptable pie. The reconstituted cherries in pie form were red in color, possessed a smooth skin texture, and a desirable cherry flavor. (See page 610).

*Flavor analysis* *Component of apple sauce*

**A volatile acidic flavor component of apple sauce.** Leonard R. Mattick, Robert S. Shallenberger and James C. Moyer.

The major steam distillable acid of apple sauce has been

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isolated and identified as n-caproic acid, a very unpleasant smelling acid. When n-caproic acid was added in varying amounts to a relatively flavorless apple sauce, a taste panel could detect differences of 0.45 mg. of n-caproic acid/100 g. of apple sauce. Concentrations higher than 8 mg/100 g. of sauce were offensive to 100% of the panel, whereas in the lower concentrations of 2 to 3 mg/100 g. of sauce, it contributed to the flavor of the apple sauce. A series of commercial apple sauce samples were analyzed for their caproic acid concentration, and subjected to a taste panel. Good correlation between the average score assigned to the sauce by the panel and the n-caproic acid concentration was obtained. Storage appears to affect the concentration of this acid markedly. A steady increase in the concentration of the acid is noted with time. (See page 613).

*Radiation, addition of oxygen scavenger* — *Precooked meat*

**Influence of short term high temperature storage with and without oxygen scavenger on the acceptability of precooked irradiated meat.** A. M. Pearson, L. E. Dawson, L. J. Bratzler and R. N. Costilow.

Effects of short term high temperature storage upon the acceptability of precooked irradiated beef, chicken, pork and veal were studied. Effects of adding an oxygen scavenger (glucose oxidase) to all items except chicken were also determined. Results for precooked meat radiated at $2.79 \times 10^6$ rads indicated: (1) pork showed little or no adverse effects from irradiation while beef, chicken, and veal were markedly less acceptable, (2) the acceptability scores for all cooked irradiated meats studied with the exception of pork appeared to improve with storage at room temperature or above, (3) the oxygen scavenger did not significantly influence acceptability, but there was a trend for added oxygen scavenger to result in higher mean scores, (4) loss of texture was apparent on storage; this appeared to be a function of time and temperature. (See page 616).

*Consumer study* — *Enriched rice*

**Consumer reaction to rice enriched with riboflavin.** E. J. Lease, L. D. Malphrus, R. K. Malphrus, and J. G. Lease.

Rice enriched with a powdered premix so that it contained the amount of riboflavin specified in the Federal standard sold as well as rice with no riboflavin added. In 2 separate marketing trials, a total of approximately 2 tons of rice (50% enriched, 50% fortified), packaged in 3-pound cellophane bags, and displayed without preference to either type, was sold in 5 supermarkets in South Carolina, 3 of which are located in the coastal area where rice consumption is very high. No consumer complaints or comments were received. In panel studies using cooked rice, under ordinary lighting, 71% of the panel members had no color preference for either enriched rice or fortified rice. Under a 250-watt Mazda lamp, 63% of the panelists had no color preference between the two types of rice. The paired comparison method was used in both tests. Of the homemakers preparing the two types of rice in their homes, 80% indicated that they found no difference due to color; of the remaining 20%, 6% found more color in the fortified rice, and 14% found more color in the enriched rice. Only 3%, in the latter group, objected to the color. Homemakers preparing enriched and fortified precooked rice indicated no awareness of color: 67% preferred the enriched rice; 27% preferred the fortified rice, 6% expressed no preference. The basis for the preferences was on qualities other than color. When these same homemakers were asked to comment on color specifically, none found it objectionable. It appears that consumers will readily accept rice enriched by the powdered premix method whereby riboflavin as well as thiamine, niacin, and iron is added to the level specified in the Federal standard. (See page 620).

*Storage study* — *Potato granules*

**Storage characteristics of potato granules.** R. M. Stephenson, T. Sano and P. R. Harris.

Potato granules are subject to non-enzymatic browning, oxidative rancidity, and other deteriorative changes. This paper covers extensive storage study conducted to determine the effect of moisture content, storage temperature, inert gas packaging, sulphite salts and antioxidants. Moisture contents in the range of 8%-10% retard rancidity but make the granules subject to non-enzymatic browning at elevated temperatures. At room temperature storage, color is stable even at 10% moisture. Storage in oxygen atmosphere allows rancidity to develop quickly. Storage in inert gas atmosphere prevents rancidity but has limited packaging application. Sulphite salts are essential in protecting color during processing and are required at levels low enough not to be an adverse factor in flavor. Some antioxidants are very effective in protecting against off flavor and aroma at concentrations as low as 5 p.p.m. or less. (See page 622).

*Military feeding* — *Instant bread mix*

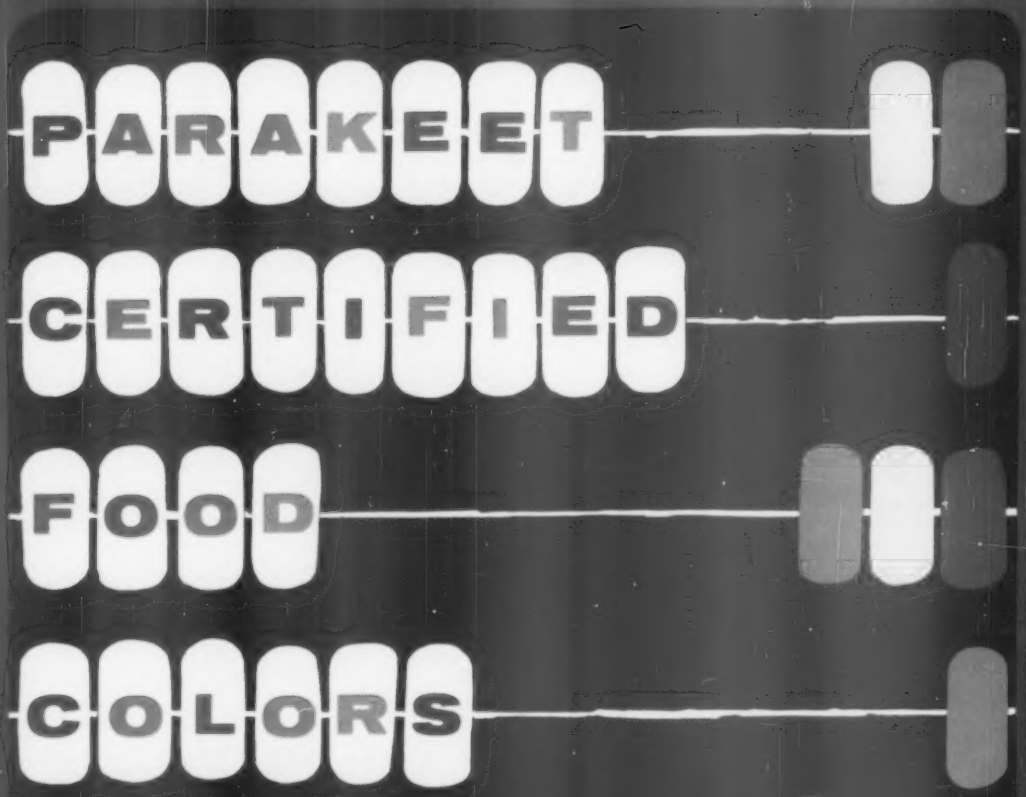
**Modern baking concepts for troop feeding.** Samuel A. Matz, Jason Miller, and Julius Davis.

Atomic warfare would involve supplying bread to rapidly moving and highly dispersed units composed of relatively small numbers of men. It is difficult to adapt conventional bakeries to the conditions because the usual method of bread preparation involves repeated manipulation of large volumes of dough which must be held at controlled temperatures for relatively long periods. To circumvent these difficulties, an "instant" bread mix leavened by a chemical system and flavored with additives has been developed. This mix is suitable for use in a continuous dough mixer and can be completely prepared for the oven in 10 minutes. The necessary features of a proposed field bakery utilizing this mix are described. (See page 625).

*Protein supplement* — *Vital gluten*

**Functional properties of vital gluten.** Walter A. Carlson and Elliott M. Ziegenfuss.

Vital gluten is now widely used as a concentrated source of protein (80%). Many of the applications, both present and future, take advantage of the functional properties that are inherent with wheat protein extracted from flour by a washing process and carefully dried to retain the "vital" characteristic. This study identifies and illustrates some of these properties, including those of binder, liquid absorber (both water and oil), continuous film forming agent, and others. (See page 629).



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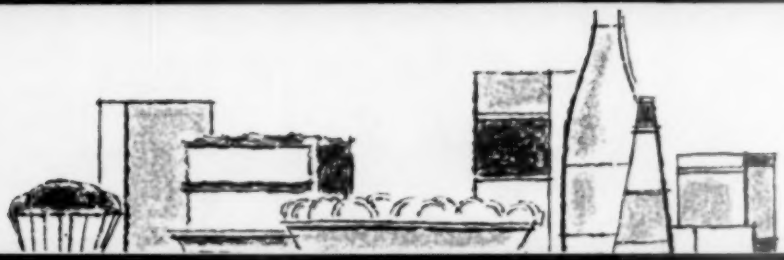

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WORLD'S LARGEST SUPPLIERS OF VANILLIN

# The Chemistry, Microbiology and Physics of Grain Storage[a,b]

**W. F. Geddes**

Department of Agricultural Biochemistry, University of Minnesota, St. Paul, Minnesota

THE IMPORTANCE of cereals in the growth of civilization has depended in large measure upon their excellent keeping qualities when stored in a relatively dry state. Under unfavorable conditions of harvesting, however, the moisture content of the grain may be sufficiently high to permit various types of deterioration during storage. The hazards are increased in long-time bulk storage. An understanding of the scientific principles of grain storage is of great importance during this era of surplus production.

Grain storage studies at the Minnesota Agricultural Experiment Station were initiated by Dr. C. H. Bailey in the Department of Agricultural Biochemistry in 1916. The author became associated with these researches in 1938. When the importance of fungi in the deterioration of grain was fully realized, a cooperative research program was established with Dr. C. M. Christensen, Department of Plant Pathology and Botany. This paper will be confined to a general review of the researches on grain storage conducted at the Minnesota Station during the past 20 years.

## THE ROLE OF MOLDS IN GRAIN RESPIRATION AND DETERIORATION

Respiration is common to the vast majority of living organisms, and a study of the respiratory rate of grain under various conditions provides a laboratory means of determining the significance of different variables involved in grain storage. Under aerobic conditions oxygen is absorbed and such nutrients as carbohydrates and fats are oxidized, with the release of energy and the formation of carbon dioxide and water as end products. Partial oxidation of these substances can also occur in living cells without the use of molecular oxygen with the formation of such end products as carbon dioxide, ethyl alcohol and various acids. The method commonly employed by earlier workers for measuring grain respiration was to seal weighed quantities of grain of known moisture content in a closed container and incubate it at constant temperature for 3 to 4 days. At the end of the trial, the accumulated carbon dioxide was determined. In dry grain free from insects, the average rate of carbon dioxide production was very low and changed little with increasing moisture content until a critical moisture range was reached above which the respiration rate accelerated very rapidly. Respiration curves do not serve to indicate whether or not grain will actually heat in storage because such factors as the temperature and soundness of the grain and the size and shape of the bulk are also involved. However, grain at moisture levels where respiration is enhanced represents a potential storage hazard. Critical moisture values for the cereal grains varied between 14 and 15% whereas that for flaxseed was somewhat under 11%; these data were of great value in establishing the Official Grain Standards. Although several of the early investigators noted that various fungi were present on the surface of grain and within the seed coats, their role in grain respiration was not understood. Some workers attributed the increased respiration above the critical moisture levels to an increase in the metabolism rate of the living seed; others believed that molds were primarily responsible *(27)*. In the researches of the author and his associates major emphasis has been placed on studies designed to elucidate the significance of molds in grain storage. Insect-free grain was used throughout.

A multiple respirometer was devised in which grain held at constant moisture and temperature was aerated continuously at controlled rates *(19)*. The effluent air was measured at 24-hour intervals and a sample analyzed for carbon dioxide and oxygen. In this way data were obtained for the oxygen and carbon dioxide content of the effluent air, total oxygen consumption, total carbon dioxide production and the respiratory quotient (ratio of the moles of carbon dioxide produced to the moles of oxygen consumed). Using this apparatus, low and virtually constant respiratory rates were obtained in experiments with wheat, corn and soybeans when the moisture contents of these grains were below about 14% *(1, 3, 16, 20, 22)*. Small increases in moisture content above this value were accompanied by respiratory increases after a lag period of several days after which equilibrium conditions were approached. Further increases in the moisture content of the grain shortened the lag period and increased the ultimate rate of respiration. Respiration-time curves for high moisture grain were similar in form to a microbiological population growth curve. Mold counts showed that increases in respiratory rate were associated with the growth of certain species of *Aspergillus* and *Penicillium*. The so-called critical moisture values at which the respiration increased rapidly and such biochemical changes as loss in viability, increase in fat acidity, and decrease in nonreducing sugars became more pronounced were found to correspond with the minimum relative humidity (approximately 70 to 75%) at which the most xerophytic species of molds present on and in the grain would grow. Moreover, suppression of mold growth with fungistatic agents prevented the sharp increase in respiration, decrease in viability and marked chem-

[a] Paper No. 985 of the Miscellaneous Journal Series, Institute of Agriculture, University of Minnesota, St. Paul.

[b] Nicholas Appert Award Address delivered at National Meeting, Chicago, Illinois, May 28, 1955.

ical deterioration which invariably occurred at favorable temperatures when grain was stored at moisture contents exceeding the critical range *(17)*.

Direct experimental evidence on the important role played by molds was obtained in 1954 with a white wheat of high viability free of any internal mold infection. Molds on the surface were destroyed by mild treatment with sodium hypochlorite. The respiratory rates of the mold-free wheat measured over an 18-day period at 35° C. and moisture levels ranging from 15 to 31% were quite low and for each moisture value they were rather constant with time *(14)*. In contrast, the respiration of other lots of the original wheat at the same series of moistures but which had been inoculated with a mixed culture of molds from moldy wheat, markedly increased after a few days. Large increases in fat acidity and decreases in non-reducing sugars occurred in the moldy samples but only slight changes were observed in the mold-free wheat. These experiments provided a clear-cut distinction between deteriorative processes inherent in the seeds themselves and those produced by the normal microflora on and within the seed.

## MINIMUM MOISTURE CONTENTS REQUIRED FOR MOLD GROWTH

In the growth of microorganisms that part of the water which is free to exert vapor pressure is of major significance. In biological materials some of the water molecules are tightly adsorbed on the surfaces of the biocolloids and are more closely packed than in water in the liquid state. The fraction which is considered "free" is most conveniently defined in terms of the water activity (the vapor pressure of the moisture in the grain relative to that of pure water) or the relative humidity (when expressed on a percentage basis). Grain and air are in equilibrium when the water vapor pressure in the grain is equal to that in the air.

Microorganisms vary widely in the minimum relative water vapor pressures at which they will grow. Bacteria are hydrophytes and most species and strains require relative humidities of 95% or higher for growth. At 95% relative humidity and 25° C. the cereal grains contain about 21 to 23% moisture so that bacteria are not a factor in spoilage and deterioration at the moisture contents normally encountered even in damp grain. Many of the mold species commonly found on grain are xerophytes with minimal relative humidity requirements of 80% or lower *(3–8, 31–33)*. In respiration trials, which are normally conducted over a period of 10 to 20 days, *Aspergillus flavus* and some *Penicillium* species will grow on wheat at 80% relative humidity (about 16.0% moisture), whereas *A. glaucus* will grow at about 75% relative humidity and *A. candidus* at a slightly higher humidity. As has been shown in England some species of *Aspergillus* will develop after a prolonged latent period at moisture contents in equilibrium with relative humidities as low as 65%. The reason that critical moisture levels of about 14 to 15% found in short-time respiration trials are not safe for prolonged storage of cereals is apparently associated with the finding that molds will invade grain when stored for several months at moisture levels below 15.0%. Of particular significance is the discovery of Christensen and coworkers in 1955 that *Aspergillus restrictus*, not heretofore found in wheat or other grains, will invade wheat and barley stored in the laboratory at moisture contents as low as 13.5% for 16 months *(24, 31)*. Later observations reveal that it will develop at 13.2% moisture. This species grows very slowly and is not observed at moisture levels which permit the growth of other species. These observations imply that the maximum moisture content for long-time storage of wheat and barley should not exceed 13.0%. The grain temperature is also, of course, an important factor. The optimum temperature for the molds responsible for grain deterioration ranges between 29.4 and 35° C. (85 to 95° F.) and cool wheat has been safely stored during the winter at the head of Lake Superior at moisture contents in the order of 16%.

## INFLUENCE OF OXYGEN AND CARBON DIOXIDE CONCENTRATION ON MOLD GROWTH AND GRAIN DETERIORATION

When respiration trials are conducted with insufficient aeration the maximum respiration potential is not achieved. The question arises whether the decrease in oxygen concentration or the accumulation of carbon dioxide is the more important factor. Respiration trials have been carried out with two series of gas mixtures *(26)*. One comprised mixtures of oxygen and nitrogen containing from 0.2 to 21% oxygen; the other contained 21% oxygen and varying quantities of carbon dioxide and nitrogen to provide carbon dioxide levels of 0.02 to 79% by volume. These mixtures were drawn through viable wheat maintained at 18% moisture and 30° C. for 16 days. As the oxygen concentration was lowered, mold growth, germ damage, fat acidity and respiration rate all gradually decreased. Even at 0.2% oxygen, some mold growth occurred; a respiratory quotient of 8.8 for this sample indicated that anaerobic metabolism was taking place. In the presence of 21% oxygen, increasing levels of carbon dioxide had little effect upon respiration rate until the concentration exceeded 13.8 to 18.6%, when a very sharp and marked inhibition of respiration, mold growth, and development of fat acidity occurred. At large carbon dioxide concentrations (50 and 79%) the viability of the wheat remained high and there was little or no germ damage.

## STUDIES ON GERM-DAMAGED OR SICK WHEAT

Among the most poorly defined types of damage associated with the storage deterioration of grain is the condition known as "germ-damaged" or "sick" wheat. This condition is manifested by kernels which have a dull appearance and the germs or embryos exhibit various degrees of discoloration from light brown to black. The "sick" kernels are not viable and the germs are invariably heavily invaded with molds *(15, 23, 33)*. Such wheat yields flour of inferior color and baking quality.

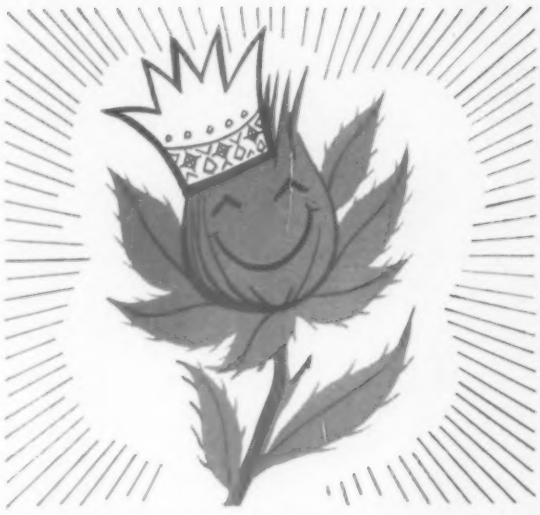
Commercial experience reveals that the develop-

ment of germ-damaged wheat is particularly prevalent after wet harvests and usually makes its appearance after storage in large quantities for some time. Although molds are present in large numbers, there was considerable question whether they could be the primary cause of the condition since elevator operators have reported that germ damage sometimes develops in stored wheat which, at the time our studies were initiated, was regarded as too low in moisture to support the growth of molds. Moreover, there was some evidence in the literature that germ damage can occur even when mold growth is prevented by fungistatic agents or by storing wheat in an inert atmosphere.

However, exposure of wheat to short periods of high moisture during or subsequent to harvest might promote the invasion of the seed by molds. The enzymes which were synthesized could perhaps cause deteriorative changes even though the wheat was subsequently stored at a "safe" moisture content. This was tested by storing surface-disinfected and mold-inoculated samples from a lot of sound wheat at approximately 14% moisture and room temperature (23 to 25° C.) for one year after being held at 15, 18, and 21% moisture for 5 to 15 days *(29)*. The most severe preliminary treatments, especially in the presence of heavy mold contamination, decreased the viability of the grain but there was little evidence of "sick" wheat immediately after treatment. However, upon subsequent storage at 14% moisture there was a progressive increase in the percentage of "sick" wheat, particularly in the mold-inoculated samples. Further experiments demonstrated that wheat heavily infested with molds will show increases in germ damage and fat acidity even when stored at 13 and 12% moisture *(4, 12, 29)*. In these experiments, the rate of deterioration was markedly accelerated by increasing the storage temperature from 75 to 100° F. (23.9 to 37.8° C.). These results, in conjuction with the subsequent finding of *Aspergillus restrictus* in wheat stored at 13.5 to 14.5% moisture for 7 to 8 months, provide a rational explanation for the observations of commercial operators.

## STUDIES ON THE EFFECTIVENESS OF AN INERT ATMOSPHERE IN PREVENTING GRAIN DETERIORATION

In recent years there has been considerable interest in the storage of grain in air-tight or hermetically sealed bins. In a sealed system, the respiratory processes of high-moisture grain with its associated molds (and sometimes insects) would soon deplete the oxygen supply and increase the carbon dioxide content of the interseed atmosphere to a point where these biological agencies would be inhibited and spoilage would thus be prevented. Indeed, reports have been published in which wheat, rice and corn have been safely stored under sealed conditions at moisture contents which would normally result in rapid deterioration. However, these reports almost invariably mention that the grain had a sour odor. In 1948, some preliminary experiments involving the storage of wheat in sealed containers equipped with manometers were

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carried out at the University of Minnesota. At moisture levels above about 16%, strong positive pressures developed after several days. These pressures revealed that the gaseous exchange involved respiratory quotients exceeding 1.0 and were indicative of anaerobic metabolism; moreover, these samples had a disagreeable sour odor.

Recently, systematic studies have been carried out in which sound viable wheat containing 13 to 18% moisture (in 1.0% increments) was stored at 20° C. and 30° C. under atmospheres of either air (renewed daily) or tank nitrogen (0.04% oxygen present) for 36 weeks *(9)*. In the trials under nitrogen at 30° C., anaerobic metabolism occurred and the samples lost viability at the same rate as corresponding samples stored in air. Although mold growth was inhibited and fat acidity increased more slowly in the nitrogen-stored samples, germ-damaged kernels developed at a comparable rate to the air-stored samples. At 20° C., however, the decreases in viability and appearance of germ damage were less in the nitrogen-stored samples. These results show that germ damage can result from the storage of wheat in the absence of mold growth, particularly at high storage temperatures. Storage in a sealed or inert atmosphere will prevent heating and rotting and may be utilized for preserving high-moisture grain for feeding purposes; however, the occurrence of anaerobic fermentation and the resulting sour condition offer little promise for preserving cereals containing excess moisture which are to be utilized for processing human foods.

## METHODS FOR DETECTING DETERIORATION IN WHEAT

A number of tests may be used to determine the "commercial condition" of grain and to predict its future storage behavior. Mold counts and viability tests indicate whether incipient deterioration has developed and fat acidity, as well as non-reducing sugar content, serve as measures of the extent of the actual damage which has already occurred. Tests of this nature have their limitations in practical elevator operation but are to be preferred to estimations of germ damage made by observing the extent of discoloration. Visual examinations of this nature are highly empirical and fail to detect the early stages of deterioration which precede the actual appearance of discoloration. Several attempts have been made to develop biochemical methods which would be more reliable and convenient indices of storage behavior than those at present available. A decrease in viability is one of the first changes to be detected in grain storage and studies have been conducted on the utility of the measurement of dehydrogenase activity as a means of estimating viability *(25)*. This test is based on the reduction of 2,3,5-triphenyl tetrazolium chloride to a red-colored compound (formazan) which can be extracted from the grain and determined by measuring the absorbance of the extract. Application of this test to wheat showed that the relation between absorbance and viability varied with variety, location of growth, and with the degree of mold infestation. Nevertheless, studies on 68 commercial samples of wheat gave the following correlations between different indices of deterioration *(30)*:

| | Simple correlation coefficients | | |
|---|---|---|---|
| | Fat acidity | Formazan value | Germ damage |
| Viability | −0.92 | −0.60 | −0.49 |
| Fat acidity | | −0.56 | +0.46 |
| Formazan value | | | −0.69 |

Present methods for the quantitative estimation of mold infestation in cereals determine the number of viable spores which are present. Non-viable or dormant spores are not included in the count, and appreciable vegetative growth may occur under suboptimal conditions without producing any viable spores. It would seem that a quantitative chemical method for estimating mold mycelia in wheat might be a better index than spore count of the actual degree of mold infestation. The vegetative cells of many species of mold fungi contain thick chitinous cell walls and in preliminary studies significant differences have been obtained between the glucosamine contents of wheat samples with high and low degrees of infestation *(11)*. The determination is rather involved, however, for routine use. Recent experiments have revealed that marked increases in inorganic phosphate and decreases in phytic acid phosphorus occur when wheat undergoes deterioration *(10)*. These increases occurred in wheat which had become non-viable due to storage either in air or nitrogen and are apparently due to wheat phytase activity. The determination offers some promise of serving as a useful index of poor previous storage conditions and of future storage hazards.

## HEATING OF STORED GRAINS

The rise in temperature which occurs in cereals or other materials without any external cause has long been called "spontaneous" heating. Cereal grains stored at moisture contents below those in equilibrium with about 75% relative humidity are not subject to heating over normal storage periods, unless infested with insects. The respiratory activity of the dry grain is so low that the small amount of heat produced is dissipated without a significant increase in temperature. However, if the moisture content is sufficiently high to support mold growth, or if insects are present, spontaneous heating may occur. Various workers have made laboratory studies of heat production in small lots of grain contained in Dewar flasks but temperature increases have not been observed at moisture contents where heating occurs in bulk storage. Grain is self-insulating because of its poor thermal conductivity and hence the heat loss is reduced when the mass is increased.

In recent years, several workers have constructed apparatus which permits the study of heating under conditions which are nearly adiabatic. The author and his associates studied the heating of soybeans and wheat in an adiabatic apparatus which provided for aeration and the determination of respiration *(16, 21)* at moisture contents of 18 to 22%. The heating occurred in two distinct stages, the first stage was

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largely a consequence of mold metabolism and ended when a temperature of 50 to 55° C. was attained. At this temperature the rate of carbon dioxide production fell to a low level and little temperature increase occurred. After 2 or 3 days the temperature rose very rapidly and carbon dioxide production greatly increased; in one experiment with soybeans the temperature increased 11.5° C. in one day and reached 101° C. when the experiment was terminated. This second heating phase could only be ascribed to nonbiological oxidation since autoclaved sterilized seeds heated spontaneously when stored under adiabatic conditions at about 54° C. and aerated.

## THE PHYSICS OF GRAIN DRYING

These investigations have established that the deterioration of grain in storage depends upon several factors, such as the kind and condition of the grain, the nature and extent of contamination with molds, the oxygen and carbon dioxide concentrations in the interseed gas, the moisture content of the grain, and the temperature and length of time of storage. Of these, the moisture content, along with temperature, is the main factor which determines the intensity of respiration and heat production. The only effective method for the long-time storage of grain is to hold it at a moisture content low enough to prevent molds from developing in any part of the bulk. Even grain stored in a relatively dry condition may spoil as a result of moisture migration caused by temperature differences within the mass of grain. In northern sections of the United States, the outer layers of grain decrease slowly in temperature during the fall and winter months. Grain has a low thermal conductivity and the interior of the bulk is insulated against temperature changes by the surrounding outer layers. Moisture migrates in the vapor phase from the warm interior mass to the cool upper and outer layers of grain as a result of the convection currents which are established. When the warm air cools, the relative humidity increases and the moisture content of the cool grain increases. With time, the moisture content of the upper layers may become sufficiently high to result in spoilage with the onset of warm weather in the spring. If localized heating occurs, the transfer of moisture from the hot to the cool sections of the bin is accelerated. This cause of spoilage can be avoided by "turning" the grain at intervals or by ventilating it with very low rates of air flow to prevent the migration of moisture.

Grain which contains excessive moisture for safe storage must be dried. The literature contains numerous papers on the drying of grain. Most of the experiments have been concerned with practical applications in which air at a given initial temperature and relative humidity is passed through the grain at a certain velocity. The temperature of the air decreases and the relative humidity increases as the air moves through the grain and both will attain limiting values when the relative humidity of the air is in equilibrium with the moisture content of the grain. The drying capacity of the air thus decreases as it passes through the grain. The rates at which the temperature and relative humidity change depend upon the rate at which moisture is being evaporated from the grain.

To formulate precise mathematical laws for grain drying it is essential to study the drying rate of individual kernels which are fully exposed to air of constant temperature and relative humidity. A few workers, including the author and his associates *(28)*, have conducted experiments under these conditions. However, much more extensive studies are necessary before a general mathematical formula can be developed for the precise prediction of the drying rates of bulk grain. The equilibrium moisture contents of grain at any given relative humidity decrease slightly as the air temperature increases, but the actual sorption and desorption values for the elevated air temperatures used in commerical drying are not known. The drying rate of fully exposed grain is a function of the nature, size, shape and moisture content of the kernels and the temperature and relative humidity of the drying air. In general the rate of drying is greater, the higher the grain moisture, the higher the air temperature and the lower the air humidity. These conditions increase the differential in the vapor pressure of the grain and of the air. The moisture content of the grain decreases rapidly at first and then more and more slowly until it reaches a constant value when the vapor pressure of the water in the grain and in the air are in equilibrium.

The rate of drying is limited by the rate at which moisture moves from the interior of a kernel to the surface and if the evaporation of moisture from the surface of the grain is too rapid, "case hardening" can occur which slows down the movement of moisture to the outer layers. The moisture differential between the surface and interior of the kernel sets up stresses which frequently result in fine fissures or cracks thereby damaging the grain for milling purposes. This difficulty may be obviated by drying high-moisture grain in two to three stages between which the grain is stored for several days to permit moisture equilibrium to be attained within the kernels.

## DISCUSSION

Chemical changes in stored grain occur at varying rates which depend upon the moisture content, the oxygen supply, the temperature and the degree of soundness of the grain. The majority of the changes which take place are the result of the action of the enzymes of the grain or of the fungi which are present within the seed coats. When insect-free grain is stored at moisture contents and temperatures which preclude the growth of molds, it exhibits a low respiratory activity and undergoes deterioration very slowly. At higher levels of moisture and temperature there is a marked increase in enzymatic and respiratory activity and the various chemical changes associated with deterioration occur more rapidly.

Researches are needed to determine the influence of variations in moisture and temperature within the ranges encountered in grain storage upon the activity of the many individual enzymes which play a part in grain deterioration.

The key role which moisture plays in grain storage makes it imperative to intensify investigations of methods of drying grain with minimum alterations in nutrient content and processing characteristics. Drying studies are of particular importance with corn because of the increasing use of the picker-sheller-harvester.

## LITERATURE CITED


1. Bottomley, R. A., Christensen, C. M., and Geddes, W. F. Grain storage studies. IX. The influence of various temperatures, humidities, and oxygen concentrations on mold growth and biochemical changes in stored yellow corn. *Cereal Chem.*, **27**, 271 (1950).
2. Bottomley, R. A., Christensen, C. M., and Geddes, W. F. Grain storage studies. X. The influence of aeration, time, and moisture content on fat acidity, nonreducing sugars, and mold flora of stored yellow corn. *Cereal Chem.*, **29**, 53 (1952).
3. Christensen, C. M. Fungi on and in wheat seed. *Cereal Chem.*, **28**, 408 (1951).
4. Christensen, C. M. Grain storage studies. XVIII. Mold invasion of wheat stored for sixteen months at moisture contents below 15 percent. *Cereal Chem.*, **32**, 107 (1955).
5. Christensen, C. M. Grain storage studies. XXI. Viability and moldiness of commercial wheat in relation to the incidence of germ damage. *Cereal Chem.*, **32**, 507 (1955).
6. Christensen, C. M., and Drescher, R. F. Grain storage studies. XIV. Changes in moisture content, germination percentage, and moldiness of wheat samples stored in different portions of bulk wheat in commercial bins. *Cereal Chem.*, **31**, 206 (1954).
7. Christensen, C. M., Olafson, J. H., and Geddes, W. F. Grain storage studies. VIII. Relation of molds in moist stored cottonseed to increased production of carbon dioxide, fatty acids, and heat. *Cereal Chem.*, **26**, 109 (1949).
8. del Prado, F. A., and Christensen, C. M. Grain storage studies. XII. The fungus flora of stored rice seed. *Cereal Chem.*, **29**, 456 (1952).
9. Glass, R., Christensen, C. M., and Geddes, W. F. Grain storage studies. XXVIII. Influence of temperature and moisture on the behavior of wheat stored in air or nitrogen. *Cereal Chem.*, in preparation.
10. Glass, R., and Geddes, W. F. Grain storage studies. XXVII. The inorganic phosphorus content of deteriorating wheat. *Cereal Chem.*, in press.
11. Golubchuk, M., Cuendet, L. S., and Geddes, W. F. Grain storage studies. Chitin content of wheat as an index of mold contamination and wheat deterioration. *Cereal Chem.*, in press.
12. Golubchuk, M., Sorger-Domenigg, H., Cuendet, L. S., Christensen, C. M., and Geddes, W. F. Grain storage studies. XIX. Influence of mold infestation and temperature on the deterioration of wheat during storage at approximately 12% moisture. *Cereal Chem.*, **33**, 45 (1956).
13. Goodman, J. J., and Christensen, C. M. Grain storage studies. XI. Lipolytic activity of fungi isolated from stored corn. *Cereal Chem.*, **29**, 299 (1952).
14. Hummel, B. C. W., Cuendet, L. S., Christensen, C. M., and Geddes, W. F. Grain storage studies. XIII. Comparative changes in respiration, viability, and chemical composition of mold-free and mold-contaminated wheat upon storage. *Cereal Chem.*, **31**, 143 (1954).
15. Milner, M., Christensen, C. M., and Geddes, W. F. Grain storage studies. V. Chemical and microbiological studies on "sick" wheat. *Cereal Chem.*, **24**, 23 (1947).
16. Milner, M., Christensen, C. M., and Geddes, W. F. Grain storage studies. VI. Wheat respiration in relation to moisture content, mold growth, chemical deterioration, and heating. *Cereal Chem.*, **24**, 182 (1947).
17. Milner, M., Christensen, C. M., and Geddes, W. F. Grain storage studies. VII. Influence of certain mold inhibitors on respiration of moist wheat. *Cereal Chem.*, **24**, 507 (1947).
18. Milner, M., and Geddes, W. F. Grain storage studies. I. Influence of localized heating of soybeans on interseed air movements. *Cereal Chem.*, 22, 477 (1945).
19. Milner, M., and Geddes, W. F. Grain storage studies. II. The effect of aeration, temperature, and time on the respiration of soybeans containing excessive moisture. *Cereal Chem.*, 22, 484 (1945).
20. Milner, M., and Geddes, W. F. Grain storage studies. III. The relation between moisture content, mold growth, and respiration of soybeans. *Cereal Chem.*, **23**, 225 (1946).
21. Milner, M., and Geddes, W. F. Grain storage studies. IV. Biological and chemical factors involved in the spontaneous heating of soybeans. *Cereal Chem.*, **23**, 449 (1946).
22. Olafson, J. H., Christensen, C. M., and Geddes, W. F. Grain storage studies. XV. Influence of moisture content, commercial grade, and maturity on the respiration and chemical deterioration of corn. *Cereal Chem.*, **31**, 333 (1954).
23. Papavizas, G. C., and Christensen, C. M. Grain storage studies. XXV. Effects of invasion by storage fungi upon germination of wheat seed and upon development of sick wheat. *Cereal Chem.*, **34**, 350 (1957).
24. Papavizas, G. C., and Christensen, C. M. Grain storage studies. XXVI. Fungus invasion and deterioration of wheats stored at low temperatures and moisture contents of 15 to 18 percent. *Cereal Chem.*, **35**, 27 (1958).
25. Peterson, Anne M., Cuendet, L. S., and Geddes, W. F. Grain storage studies. XXX. Colorimetric evaluation of wheat viability. *Cereal Chem.*, in press.
26. Peterson, Anne, Schlegel, Vera, Hummel, B., Cuendet,



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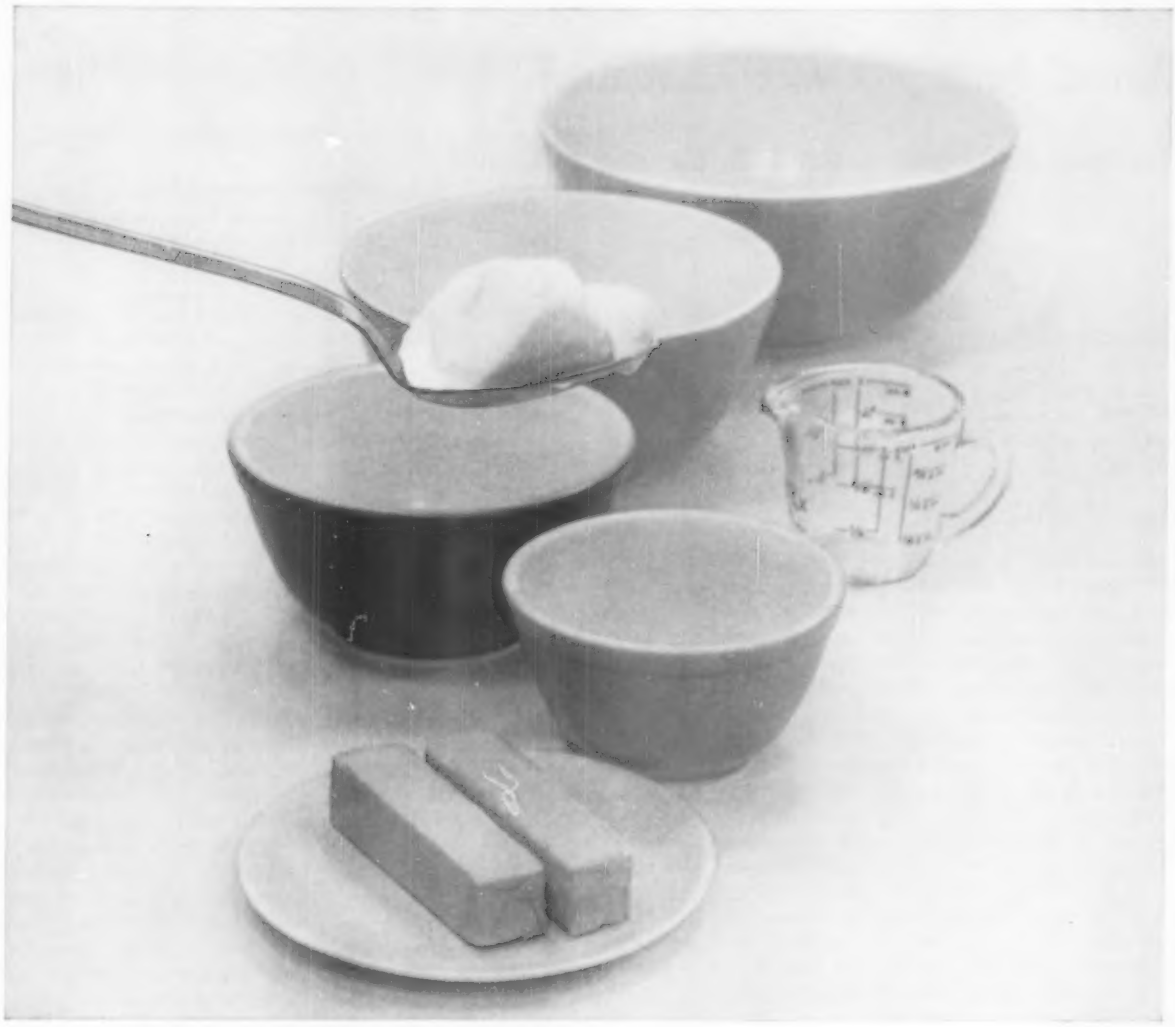
L. S., GEDDES, W. F., AND CHRISTENSEN, C. M. Grain storage studies. XXII. Influence of oxygen and carbon dioxide concentrations on mold growth and grain deterioration. *Cereal Chem.*, 33, 53 (1956).

27. RAMSTAD, P. E., AND GEDDES, W. F. The respiration and storage behavior of soybeans. Minn. Agr. Expt. Sta. Tech. Bull. 156 (1942).
28. SMITH, D. E., PIRET, E. L., AND GEDDES, W. F. Influence of air temperature, velocity, and relative humidity on the drying rate of shelled corn. *Cereal Chem.*, in preparation.
29. SORGER-DOMENIGG, H., CUENDET, L. S., CHRISTENSEN, C. M., AND GEDDES, W. F. Grain storage studies. XVII. Effect of mold growth during temporary exposure of wheat to high moisture contents upon the development of germ damage and other indices of deterioration during subsequent storage. *Cereal Chem.*, 32, 270 (1955).
30. SORGER-DOMENIGG, H., CUENDET, L. S., AND GEDDES, W. F. Grain storage studies. XX. Relation between viability, fat acidity, germ damage, fluorescence value, and formazan value of commercial wheat samples. *Cereal Chem.*, 32, 499 (1955).
31. TUITE, J. F., AND CHRISTENSEN, C. M. Grain storage studies. XVI. Influence of storage conditions upon the fungus flora of barley seed. *Cereal Chem.*, 32, 1 (1955).
32. TUITE, J. F., AND CHRISTENSEN, C. M. Grain storage studies. XXIII. Time of invasion of wheat seed by various species of Aspergillus responsible for deterioration of stored grain, and source of inoculation of these fungi. *Phytopathology*, 47, 265 (1957).
33. TUITE, J. F., AND CHRISTENSEN, C. M. Grain storage studies. XXIV. Moisture content of wheat seed in relation to invasion of the seed by species of the *Aspergillus glaucus* group, and effect of invasion upon germination of the seed. *Phytopathology*, 47, 323 (1957).


## FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

| | |
|---|---|
| 1958 | |
| December 26–31 | American Association for the Advancement of Science, Washington, D. C. |
| 1959 | |
| March 4–6 | Southeastern Conference on Better Foods, The Georgia Center for Continuing Education, University of Georgia, Athens, Georgia |
| 1959 | |
| **May 17–21** | **Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadephia, Pennsylvania** |
| 1960 | |
| **May 15–19** | **Twentieth Annual Meeting of the Institute of Food Technologists, Civic Auditorium and Hotel Whitcomb, San Francisco, California** |
| 1961 | |
| **May 7–11** | **Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York** |
| 1962 | |
| **June 17–20** | **Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Bal Harbor, Miami Beach, Florida** |

**An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.**



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# Annual Poultry Science Association

## Technical Highlights of the 47th Meeting at Cornell

**William J. Stadelman**

Department of Poultry Science, Purdue University, Lafayette, Indiana

THE 47TH ANNUAL and 50th Anniversary meeting of Poultry Science Association was held at Cornell University, Ithaca, New York, August 5th to 8th. Over 1,300 members and guests listened to 250 technical and scientific papers presented tc sections in genetics, physiology, nutrition, marketing, pathology, extension and instruction. Abstracts of all papers presented are published in the September 1958 issue of *Poultry Science*.

### Atherosclerosis in chickens

Papers presented in the genetics, pathology, extension and instruction sections were generally of only indirect interest to food technologists. From the tone of papers presented in the instruction section the problems in getting sufficient trained poultry husbandmen are about the same as getting a sufficient number of trained food technologists. In the physiology section a series of papers was presented on factors affecting the cholesterol content of the egg yolk and poultry meat. In addition there were two papers on the incidence of atherosclerosis in chickens, one by Ferguson *et al.* (Texas A & M College) and a second by Weiss (Rutgers University). A paper related to these was presented in the marketing section on the effect of the diet of the bird on fatty acid composition of the body and egg yolk fat. This paper was by Feigenhaum and Fisher (Rutgers).

### Poultry meat quality

There were several papers on quality factors of poultry meat. Essary (V. P. I) reported on a method for reducing bone darkening in frozen fryers. De Fremery and Pool (USDA) reported biochemical studies with chicken muscle as related to rigor mortis and tenderization. Holding poultry meat at temperatures above 30° C. resulted in marked increase in rate of disappearance of adenosine triphosphate and in a less tender muscle. Gamma irradiation had a marked toughening effect on pre-rigor muscle.

### Egg quality

Much of the session this year was given over to a discussion of egg quality. Reports of consumer surveys in California and Iowa were made by Sanborn and Carlin, respectively. Cotterill *et al.* (University of Missouri) reported some interesting work relative to buffering effect of egg white at different points on the pH scale. There is actually very little buffering effect in pH range from 7 to 9 which is the normal range of egg albumen in fresh market eggs. Outside of this range the egg white exhibited rather strong buffering effect. Yolk blemishes received considerable study as indicated by reports from McNally and Brant (USDA) and Mitchell and Stadelman (Purdue). Blemishes on the egg yolk which during the past several years have been attributed largely to poor feed formulation or addition of certain medicinals were found to be naturally occurring in many eggs. Factors affecting loss of albumen quality during storage were discussed by Mueller (Pennsylvania State University). He concluded that a large percentage of variation in albumen quality loss during storage could be attributed to differences in initial albumen quality, rate of carbon dioxide loss, and rate of water movement from the albumen into the yolk. Kyle and Mitchell (Purdue) reported on heritability of rate of albumen quality loss indicating that this characteristic is rather highly heritable.

There was considerable discussion at the meeting relative to use of mineral oil or other preservatives for shell treating eggs. Swanson *et al.* (Minnesota) presented the only paper on this subject. The results clearly indicated that shell treatment should be considered only as a supplement to refrigeration and not a substitute for it in marketing of quality eggs. Oiling was an effective means for improving quality of eggs when propertly handled with adequate refrigeration. Some improvement was noted when eggs were handled without refrigeration but the quality of eggs was not sufficiently good to be acceptable on a quality market.

### Improving albumen quality

Helbacka and Hall (University of Maryland) reported on a means for improving albumen quality of the freshly laid egg. The inclusion of 2% ammonium chloride in the feed resulted in an increase of about 10 Haugh units in eggs produced. Improvement in albumen quality was accompanied by a reduction in shell quality so that further work is needed to get commercial application of this means for producing higher quality eggs. Baker *et al.* reported on research at Purdue University dealing with lysozyme content of chicken egg chalazae. They reported that the chalazae were particularly rich in lysozyme and also that the structure of the chalazae did not break down at the same rate as other albumen components of the egg. This work indicates the need for further study regarding relationship of lysozyme content of eggs and rate of albumen quality loss.

There were numerous papers in the nutrition section relative to methods for improving quality of rations for poultry which would undoubtedly have bearing on rations for other animals. There were nu-

(Continued on page 17 following Technical Section)

# Sanitary Control in Processing Citrus Concentrates

## I. Some Specific Sources of Microbial Contamination from Fruit Bins to Extractors

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**Charles H. Brokaw**
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(Manuscript received May 31, 1958)

SANITATION HAS BEEN DEFINED as safe-guarding health through cleanliness. As applied to the food industry, it means that every product canned or frozen must be produced under hygienic conditions for human consumption, and must comply with local, state, and federal laws. Sanitation is an integral part of plant operation and embraces control of both microscopic and macroscopic contamination of all types. In the frozen citrus concentrate industry, microbial control starts when fruit enters the processing plant. Here, unsound fruit is removed in the grading operation, and sound fruit washed and sanitized prior to the extraction process. The sanitary condition of fruit handling equipment and the efficiency of fruit washing operation play an important role in controlling microbial population of the extracted juice. Subsequent stages of processing prior to evaporators require an efficient control program to minimize bacterial activity. This means that juice room equipment (extractors, finishers, holding tanks, etc.) must be sanitized on a routine basis. Also required is the elimination of focal pockets of contamination such as dead ends, and the use of sanitary-designed equipment.

On the sanitary aspects of processing citrus concentrates, the literature contains only a few studies with Beisel *(2)* and Brokaw *(3)* being most informative. These two authors described the manufacturing operations and discussed cleaning practices employed.

Fortunately, the pH values of citrus concentrates, which average from 3.4 to 4.0 *(4, 10)*, limit the growth of microorganisms to those capable of tolerating this acid medium. Organisms known to grow in single strength juices of these acid foods (not including lemon or lime juice) are lactic acid and acetic acid bacteria, yeasts, and molds. Of this group, organisms belonging to the genus *Lactobacillus* are of prime concern to bacteriologists. Lactic acid bacteria have been frequently implicated in the production of abnormal flavors and odors in concentrates, among which are those described as being similar to "buttermilk" *(5, 6, 8)*. Acetic acid bacteria, yeasts, and molds, on the other hand, generally do not grow rapidly enough to build up large populations under conditions that normally prevail during concentration of the juice *(13)*.

To retard gelation and separation of cloud and pulp, juice is usually flash heated either as it enters the evaporators or early in the stages of concentration *(1, 11, 12)*. This process has a beneficial effect in reducing bacterial contamination in evaporators *(13)*, but lack of sufficient heat treatment to destroy all microorganisms in the product, and the use of unheated cutback juice, have necessitated sanitary concepts which are perhaps unique to this industry.

The primary purpose of this paper is to point out some specific sources of microbial contamination in (a) handling fruit from bins to extractors, (b) juice from extractors to the evaporators, (c) concentrating and packaging, and (d) equipment sanitizing and evaporator cleaning. Because of need for detailed data, each section will be presented separately.

### PROCEDURE

The fruit surface studies reported in this paper were made in accordance with the procedure described by D. I. Murdock *et al. (9)*. Standard plating technique was employed throughout the study. Orange serum agar was used as the plating medium, and all plates were counted after 48 hours of incubation at 30° C. (86° F.).

### RESULTS AND DISCUSSION

**Fruit handling.** At most concentrate plants, fruit received is dumped on to a conveyor system, graded, stored in bins, regraded, washed, and sanitized prior to entering the extractors. The effect of each operation on fruit surface contamination was investigated in one plant over a 14-day period during the Valencia season. The averaged results (Figure 1) show the per cent increase or decrease in fruit surface microflora after each sampling station. Fruit surface contamination from bins, for example, was based on samples collected before and after use of the bins; from brush washer, from samples collected before and after this operation. It will be noted that fruit was recontaminated in the bins and by the flight elevator. The brush washer and chlorinated water rinse, on the other hand, effectively reduced fruit surface contamination. The brush washer, as the name implies, is employed to wash fruit prior to entering the extractors. This is usually accomplished by applying a detergent and /or wetting agent to the fruit entering the washer, and rinsing the fruit at the exit end with chlorinated water. The effectiveness of this phase of

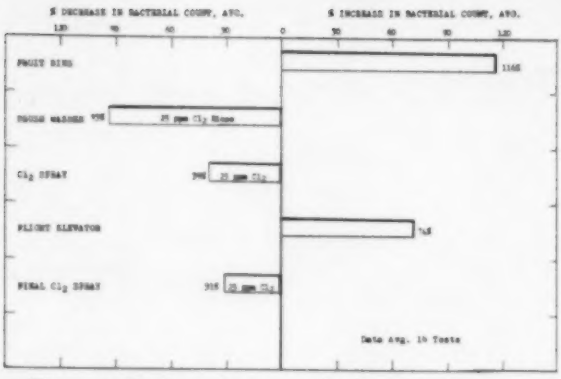


**Figure 1. Fruit surface contamination after various fruit handling operations.**

the operation on fruit surface contamination was investigated in another plant. It was noted that rinsing fruit with unchlorinated water resulted in a 79% reduction in fruit surface microflora; the 10 p.p.m. and 20 p.p.m. chlorine rinse gave 92 and 98.8% reduction, respectively. It can be seen from these data, based on the average of 6 test runs for each variable, that chlorinated water used in conjunction with the brush washer improved the sanitizing efficiency of this operation.

**Recontamination of fruit surfaces.** Recontamination of fruit surfaces occurs after sanitizing if subsequent fruit handling equipment is not kept in a sanitary condition. This may result from slimy belts, sizers, and elevators. For example, a sample of slime from a canvas flap used to provide a more even distribution of fruit entering a size grader, gave a total viable count of 368,000,000 microorganisms per gram when plated. It is apparent this material will readily increase the microbial load on any surfaces it contacts.

Conveyor belts can easily become "seeded" with microorganisms. This occurs in some plants where belts feeding fruit to the extractors travel over expanded metal. The belts become impregnated with pieces of fruit that are almost impossible to remove during the cleaning process. In other cases conveyor belts move over a series of rollers, which frequently stick and then become coated with citrus solids, resulting in the rollers contaminating the belt surfaces. A sample of this material was plated and found to contain 15,700,000 microorganisms per gram.

Equipment employed to return overflow fruit which failed to drop into extractors on the first pass, may also be a source of recontamination of fruit surfaces. This part of the operation, which usually consists of a series of conveyor belts and one or more elevators, generally is not readily accessible. Consequently, it is frequently overlooked in the cleaning process, resulting in unsanitary conditions. Pieces of fruit may accumulate on elevators, chutes, along edges of belts, etc. This material readily becomes seeded with microorganisms and recontaminates fruit it contacts. An efficient sanitation program is needed in this phase of our processing operation, as the following data indicate:

A conveyor belt, frequently found in an insanitary condition, showed that oranges leaving the belt increased approximately 4-fold in contamination over fruit entering the belt (180,000 to 530,000 microorganisms per orange, respectively, based on the average of 2 tests).

A screw conveyor, used to elevate excess fruit back to the extractor line, was difficult to clean, and split a large number of fruit. Consequently, it proved to be a serious source of microbial build-up of fruit surfaces (Table 1); resulting in the juice from No. 2 Line, which contained regular, plus overflow fruit, to be more heavily seeded with microorganisms than juice from No. 1 Line, which contained no overflow fruit (Table 2).

**TABLE 1**

**Recontamination of fruit surfaces by screw conveyor used for handling overflow fruit from extractors**

| Test No. | Screw conveyor | |
|---|---|---|
| | Entering | Leaving |
| 1 | 220,000 | 8,000,000 |
| 2 | 280,000 | 3,100,000 |
| 3 | 400,000 | 2,600,000 |
| 4 | 520,000 | 4,600,000 |
| 5 | 500,000 | 15,000,000 |

Results expressed as the number of microorganisms per orange. Data obtained over a 4-day period.

**TABLE 2**

**Juice extracted from oranges on line containing fruit recontaminated by screw conveyor**

| Test No. | Line No. 1 No overflow fruit | Line No. 2 Overflow plus regular fruit |
|---|---|---|
| 1 | 13,900 | 13,500 |
| 2 | 5,250 | 13,750 |
| 3 | 11,250 | 31,250 |
| 4 | 3,500 | 44,000 |
| 5 | 47,500 | 107,200 |

Results expressed as number of microorganisms per ml. Samples collected before finishers over a 5-day period.

Baffle plates, used in most concentrate plants to shunt overflow fruit from one conveyor belt to another, may also be a source of contamination. This occurs when fruit becomes impinged on this plate, splits, and lodges between it and the conveyor belt. It was noted in one operation that oranges, which accumulated at this point to a depth of 5 to 6 inches, continually sloughed off and were then conveyed back to No. 2 Line of extractors. Plate counts made with juice from this line were higher than those made from No. 1 Line, which received no overflow fruit. However, when operating personnel in the juice room started removing fruit from the baffle plate every 4 hours the level of contamination of juice from each line was comparable, as the data in Table 3 indicate.

**TABLE 3**

**Contamination of juice from two extractor lines showing effect of fruit damaged on baffle plate used on Line No. 2 in conjunction with handling overflow fruit from extractors**

| Date | Line No. 1 No baffle | Line No. 2 With baffle (Fruit not removed) | Date | Line No. 1 No baffle | Line No. 2 With baffle (Fruit removed) |
|---|---|---|---|---|---|
| Jan. 14 | Not operating | 424,000 | Jan. 18 | 1,000 | 7,000 |
| Jan. 15 | 15,000 | 80,000 | Jan. 19 | 1,000 | 1,000 |
| Jan. 16 | 3,000 | 212,000 | Jan. 20 | 1,000 | 2,000 |
| Jan. 17 | 4,000 | 45,000 | Jan. 23 | 67,000 | 61,000 |

Results expressed as number of microorganisms per ml. of juice. All samples collected before finisher in each line.

Finally, recontamination of fruit surface may also occur just before fruit enters the extractors if they are not properly cleaned in their entirety. In the Brown machine, this may result from an accumulation of citrus solids in fruit hoppers, and/or fruit elevator which conveys individual fruit to the cutting knives; and in the F.M.C. extractor, from the vibrating fruit feeder and/or bar lift.

**Fruit grading.** Quality control starts with fruit entering the plant. If unsound fruit, composed of a large percentage of drops, soft deteriorated spots, splits, etc., is permitted to enter the extractors, it not only contaminates juice room equipment and evaporators, but may also result in "stale" or "old fruit" flavors in the finished product. For this reason, fruit is graded, Figure 2, before entering the bins and again before the extractors. In the initial operation, unsound fruit received at the plant is sorted out, and fruit damaged by the bins removed by the final graders. The soundness of fruit entering extractors is so important in controlling final product quality that proper grading of fruit cannot be too strongly stressed. Unfortunately, the efficiency of this operation leaves much to be desired in most plants. It is not uncommon for unsound fruit to reach the extractors.

**Figure 2. Efficient grading is essential in maintaining product quality.**

There have been few or no technological advances in fruit grading since the advent of the citrus processing industry. It has been found *(7)* that on a grading table 4 feet in width, normal fruit should move no faster than about 30 feet per minute, and at least 2 graders should be located on each side of the table. Under these conditions, fruit should move over a table at a rate no greater than 120 boxes (90 pounds each) per grader per hour for satisfactory grading. If fruit is less than normal quality, it may be necessary to reduce the ratio of fruit to graders by as much as 50%. Nevertheless, grading tables are frequently operated at speeds far in excess of this rate. Movement of fruit at 100 to 120 feet per minute is not uncommon in some plants, making it extremely difficult to grade fruit efficiently when it passes over roller conveyors at this speed. Fruit grading, unfortunately, is considered by the industry more or less a necessary evil. If a plant is shorthanded, and an extra "hand" is needed for some other task, he is usually obtained from the grading tables—thus creating a shortage of graders.

In a previous study *(9)* it was found both fruit surfaces and extracted juice from splits and deteriorated fruit were heavily contaminated with microorganisms, as indicated in the data presented in Table 4. It is quite obvious from these results, if defective fruit is not removed from the line by the final graders, it will readily seed juice extracted from sound oranges.

In another investigation an attempt was made to determine the effect of fruit quality on contamination of juice during a commercial operation. For 2 days every effort was made by the final graders to remove all defective oranges passing over the lines. During this period the fruit was considered to be "sound"—having no splits, bruises, or soft spots. The next phase of study was made over a 3-day interval when a large percentage of oranges entering the extractors contained splits, soft spots, etc., resulting from the inability of graders to remove all defective fruit. Data in Table 5 show contamination of juice collected from various sampling stations from the extractors to the cutback tank. It will be noted that juice extracted from sound fruit contained fewer microorganisms than juice extracted from poor fruit.

The above description of fruit as to degree of "soundness" is based on a casual examination prior to entering the extractors. In reporting fruit, either good or bad, no factual data were available to substantiate statements made in reference to fruit quality. To obtain this type of information, 50 oranges were collected at random after the final graders, from

**TABLE 4**

**Microflora on the surfaces and in the extracted juice of sound and defective fruit**

| Type of fruit | Contamination on fruit surfaces | | Contamination of extracted juice | |
|---|---|---|---|---|
| | Total microflora per orange | | Total microflora per ml. | |
| | Test 1 | Test 2 | Test 1 | Test 2 |
| Sound fruit | | 74,000 | | 500 |
| Drops | 64,000 | 855,000 | 29,000 | 1,500 |
| Splits | 113,700,000 | 21,400,000 | 2,800,000 | 620,000 |
| Deteriorated fruit | 3,250,000 | 44,200,000 | 9,200,000 | 3,100,000 |

**TABLE 5**

**Effect of fruit quality on contamination of cutback juice**

| Source of sample | Poor fruit[2] | | Sound fruit[2] | |
|---|---|---|---|---|
| | No. of samplings | Average org. per ml. | No. of samplings | Average org. per ml. |
| Juice after extractors[1] | 11 | 76,363 | 6 | 7,950 |
| Before finisher | 11 | 164,363 | 6 | 9,583 |
| After finisher | 11 | 173,181 | 4 | 8,825 |
| Cutback tank | 9 | 150,222 | 6 | 15,550 |

[1] Composite sample of juice from Brown Extractors before finisher.

[2] All data obtained over a single 5-day period; viz., "Poor Fruit" for 3 days and "Sound Fruit" for 2 days.

"Poor Fruit"—Containing a high percentage of soft fruit with numerous splits, bruises and soft spots.

"Sound Fruit"—Fruit supply was firm with no splits, bruises or soft spots.

a conveyor belt feeding one line of extractors. The fruit was placed in a 5-gallon container, then examined individually, and the number of defects (splits, soft spots, etc.) recorded as the per cent of "grade outs" per 50 oranges. To show the relationship between fruit quality and bacterial contamination of extracted juice, plate counts were made of the juice sampled before extractors each time fruit was examined for defects. A total of 15 samplings was made, using this procedure, over a 3-day period. Results presented in Table 6 show a definite correlation between fruit quality and bacterial contamination of the extracted juice.

**TABLE 6**

**Relationship between quality of fruit entering extractors and contamination of extracted juice**

| % Defects | Frequency of occurrence | Juice sampled before extractors Microorganisms per ml. | | |
|---|---|---|---|---|
| | | *Min.* | *Max.* | *Avg.* |
| 0 | 10 | 1,000 | 21,000 | 8,835 |
| 2 | 1 | 106,000 | 186,000 | 146,000 |
| 4 | 1 | 37,000 | 98,000 | 67,000 |
| 6 | 1 | 90,000 | 120,000 | 105,000 |
| 8 | 2 | 47,000 | 320,000 | 176,000 |

Period covered—3 days. Total samples examined—15.
NOTE: Per cent defects based on examination of 50 oranges collected at random from belt feeding one line of extractors.

In another test the "50-orange bucket method" was used to check the final graders every ½ to 1 hour over a 7-hour period. The percentage of defective fruit in 11 tests ranged from 0 to 2%, with defects being found in only 4 of the check samples. The fruit entering the extractors during this period was considered good. On another occasion, a similar examination made 4 times over a 2-hour interval showed defects in the range of 0 to 14%, with an average of 8%. Fruit in this case was judged to be of poor quality. Of course, the percentage of fruit actually being thrown out by the graders would be very small.

The need for more efficient grading is indicated, especially when the percentage of defective fruit entering extractors is high, to minimize bacterial contamination of extracted juice. Since it has been shown that all defects are not removed during normal plant operations, pre-grading individual loads may be necessary to correct this situation. Loads containing numerous defects could be accumulated, then passed over grading tables at a slower rate of speed and a concerted effort made to remove all unsound fruit. The 50-orange bucket method, or some similar procedure, could also be employed to check grading efficiency.

It is obvious from our experience and, indeed, it is axiomatic that quality of the finished product must commence with use of good fruit, properly prepared for processing. Later control or manufacturing efforts will not restore good flavor or assure freedom from sanitary defects if these primary raw material requirements have not been fully met.

## SUMMARY

Each fruit handling operation was investigated to determine its effect on fruit surface contamination. It was found that fruit is recontaminated by bins and flight elevators. The brush washer and chlorinated water rinses effectively reduced fruit surface contamination. The result of these sanitizing operations is minimized, however, if subsequent fruit handling equipment is not kept in a sanitary condition. Slimy fruit sizers, conveyor belts, especially those in the juice room, are all contributing factors. Each unit operation of the fruit handling system must be carefully watched to prevent contamination of extracted juice.

The importance of an efficient fruit grading system is discussed. Data are presented to show correlation between fruit quality and microbial load of extracted juice.

## LITERATURE CITED

1. ATKINS, C. D., AND ROUSE, A. H. Time-temperature relationships for heat inactivation of pectinesterase in citrus juice. *Food Technol.*, **7**, 489 (1953).
2. BEISEL, C. G. How frozen concentrate biochemists are working out the fruit bugs. *Food Eng.*, **23**, 82 (1951).
3. BROKAW, CHARLES H. The role of sanitation in quality control of frozen citrus concentrates. *Food Technol.*, **6**, 344 (1952).
4. CAMERON, E. J., AND ESTY, J. R. Comments on the microbiology of spoilage in canned foods. *Food Research*, **5**, 549–557 (1940).
5. HAYS, G. L. The isolation, cultivation, and identification of organisms which have caused spoilage in frozen concentrated orange juice. *Proc. Fla. State Hort. Soc.* (1951).
6. HAYS, G. L., AND REISTER, D. W. The control of "off-odor" spoilage in frozen concentrated orange juice. *Food Technol.*, **7**, 383 (1952).
7. Minute Maid Corporation. (Unpublished laboratory records).
8. MURDOCK, D. I., TROY, V. S., AND FOLINAZZO, J. F. Development of off-flavor in 20° brix orange concentrate inoculated with certain strains of lactobacilli and leuconostoc. *Food Technol.*, **6**, 127 (1952).
9. MURDOCK, D. I., FOLINAZZO, J. F., AND BROKAW, CHARLES H. Some observations of gum-forming organisms found on fruit surfaces. *Proc. Fla. State Hort. Soc.*, 278 (1953).
10. PILCHER, R. W. *The Canned Food Reference Manual.* 3rd ed. 1947. American Can Co., New York, N. Y.
11. ROUSE, A. H., AND ATKINS, C. D. Heat inactivation of pectinesterase in citrus juices. *Food Technol.*, **6**, 291 (1952).
12. STEVENS, J. W., PRITCHETT, D. E., AND BAIER, W. E. Control of enzymatic flocculation of cloud in citrus juices. *Food Technol.*, **4**, 469 (1950).
13. VAUGHN, REESE H., AND MURDOCK, D. I. Sanitary significance of microorganisms in frozen citrus products. *Am. J. Public Health*, **46**, 886 (1956).

# Use of a Light-Screening Agent for Retarding Oxidation of Process Cheese*

(Manuscript received May 31, 1958)

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THE PROBLEM OF FAT OXIDATION by photochemical action resulting in off flavors has been recognized by food chemists and food producers for many years. These defects have been variously described as rancidity, tallowiness, fishiness, cardboard flavor, and oxidized flavor.

Coe and Le Clere *(8)* in 1932 attributed rancidity to the ultraviolet light range of the spectrum. They described black or green containers as a means of solving this difficulty. Coe *(7)* extended this work to an investigation of several color filters of blue, purple, blue-green and shades of red as protection against oxidation of salad oils, mayonnaise, butter, lard and potato chips. He proposed the use of colored wrappers and bottles to screen out active wavelengths.

Buruiana *(6)* demonstrated the oxidation of milk by sunlight in 1937. He described this defect as fishiness. During the same year Stebnitz and Sommer *(17)* described the catalytic effect of light in the oxidation of butterfat. Later in 1937 Stebnitz and Sommer *(18)* showed that fat composition influenced the susceptibility of the fat to light oxidation. Templeton and Sommer *(20)* proposed light-screening wrappers for the prevention of fat oxidation in processed cheese. In 1938 Barkworth *(1)* demonstrated that exposure of milk to sunlight resulted in a cardboard-like flavor in milk.

Light filtering methods gained more recognition in 1939 when Barton and Davies *(2)* published their results on the use of colored samples of cellophane to screen ultraviolet light from olive oil. They described two factors in light-screening: (a) the quantity of light, particularly ultraviolet, transmitted by cellophane, and (b) the stability of the screening dyes. They made the statement that ultraviolet rays were the most responsible portion of the spectrum for catalyzing fat oxidation. In 1942 Hood *(11)* proposed the wrapping of butter in light excluding materials.

A British patent was issued to Berry and Pritchard in 1945 *(3)* for a cellophane film containing a finely suspended salt of bis-(p-amino-benzoyl)-4-4′ diamino stilbene -2-2′ disulfonic acid to screen out light. British Cellophane Limited *(5)* received a similar patent in 1946.

Coe *(9)* in the United States received a patent in 1947 for incorporating dyes in wrapping materials. These dyes are reported as screening out light between 6300 and 6700 and below 4900 Ångstrom units. The same year, 1947, Gluck and Barany *(10)* were authors of a patent assigned to Dufay-Chromex Limited of Great Britain which utilized chemicals having the general formula RCH:NH:CHR′. The R and R′ were substituted or unsubstituted aromatic groups or heterocyclic or aliphatic groups.

An Italian patent *(19)* was issued in 1950 for gelatin or cellophane sheets impregnated with nickel and cobalt salts to screen out ultraviolet wavelengths. Various hydroxy benzoates and esters of benzoic acid were described by Meyer and Gearhart *(12)* in 1951 as ultraviolet inhibitors for transparent plastics of the cellulose butyrate types.

Pearl *(13)* in 1952 obtained a patent for coating wrapping materials with 3 methoxy-4-hydroxybenzoic acid. This coating was for the purpose of making the wrapping materials impervious to ultraviolet. The same year compounds familiar to us as the suntan lotions were patented. Wheelock *(21)*, the author of this patent, utilized a group of organic compounds known as carbo-styrils. This patent also covered the use of these compounds in transparent films.

Riley *(14)* obtained a patent in 1953 for dyes reported to be selective in light transmission ranges between 6300 and 7500 and capable of absorbing light below 4900 Ångstrom units.

Dr. G. G. Rumberger *(15)* of Marathon Corporation was issued a patent in 1956 for the use of diaryl ketones for making wax compositions stable in the presence of light.

During 1953 a comprehensive study of mold growth on packaged cheese was carried on in our laboratories. While making this study we consistently observed the occurrence of oxidized flavors in natural cheese which had been exposed to fluorescent light in retail-type dairy cases. Our attention was turned to process cheese in 1954 and we observed the same oxidative changes. The oxidized flavor does not become apparent in natural cheese until after 4 days exposure to light. By the 9th day the cheese becomes inedible. Process cheese, however, will show an oxidized flavor within 48 hours.

Over the past several years we have investigated various colored films and chemical compounds for filtering the portions of light responsible for oxidized flavors. Colored films which screen out light are not attractive colors for the wrapping of cheese. Some customer resistance to opaque films has been reported by sales and advertising people. With these things in mind, we investigated the use of light-screening chemicals.

The ones which seemed most applicable were substituted benzophenones. These were obtained from Antara Chemicals of New York. The one most suited to our purposes was called Uvinul 490.

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, May 28, 1958.

## EXPERIMENTAL

Uvinul 490 was coated on cellophane sheets in 4 different concentrations. These concentrations were 0.25, 0.50, 1.0 and 10% levels of the wax coating normally placed on the type of cellophane wrapper used. These were coated on the film in a solvent before the waxing of the film. Cheese wrappers were made from the coated film and then process cheese was wrapped with the treated films. Untreated films were used as controls. The wrapped cheese was then stored in a dairy display case at 45° F. The exposed cheese was so arranged that the surface of each sample was exposed to one-hundred foot candles of fluorescent light. Samples were removed at 24, 48, and 64 hours and tested for oxidation by the thiobarbituric acid test. The test as used in our laboratory is a modified version of the test reported by Sidwell *et al. (16)*. These samples were also submitted to a panel of cheese tasters known to recognize the oxidized flavor.

All rolls of wrapper film used for cheese wrapping were checked for light-screening ability on a DK Recording Beckman Spectrophotometer by comparison to the untreated film.

## DISCUSSION AND RESULTS

Results obtained by light transmission through the treated samples are shown on the graph in Figure 1. The 10% concentration absorbed most of the light in the ultraviolet range. The 0.25% concentration permitted more ultraviolet light to pass through the wrapper but the absorption was still sizeable in the lower ranges. At the 10% level the cost of addition of Uvinul was calculated to be in the range of several cents per wrapper. However, the cost at the 0.25% level was of the order of 0.2 cents per wrapper. Because of these facts, it was decided to determine what advantage in time was gained at all levels. Table 1 gives these results.

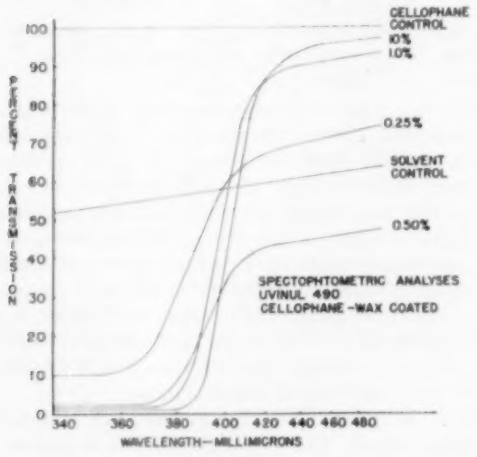


Figure 1

The coating was done on unprinted plain cellophane wrappers. Previous experiments with colored cellophane wrappers had given a set of values which are shown in Table 2.

Based on this knowledge, printed colored wrappers were tried in combination with Uvinul treated wrappers at the 0.25% level. White, light blue, and dark blue wrappers were chosen because the cheese could be seen through these. The results of this test are shown in Table 3.

**TABLE 1**

**Process cheese wrapped in Uvinul 490 treated wax-coated cellophane**

| Type of wrap | Concentration | Exposure time | | |
|---|---|---|---|---|
| | | 12 hours | 24 hours | 48 hours |
| | (%) | | | |
| Cellophane | | Strongly oxidized | Strongly oxidized | Strongly oxidized |
| Solvent coated | | Mildly oxidized | Strongly oxidized | Strongly oxidized |
| Uvinul 490 | 0.25 | Normal | Normal | Slightly oxidized |
| Uvinul 490 | 0.50 | Normal | Normal | Very slightly oxidized |
| Uvinul 490 | 1.0 | Normal | Normal | Very slightly oxidized |
| Uvinul 490 | 10 | Normal | Normal | Very slightly oxidized |

**TABLE 2**

**Light transmission through colored cellophane films**

| Color | Transmission ranges wavelength—millimicrons |
|---|---|
| Dark brown | Essentially none |
| Dark blue | 350–480 |
| White | 350–600 |
| Light blue | 400–550 |
| Dark orange | 550–600 |

**TABLE 3**

**Oxidation of process cheese protected by colored, printed plus 0.025% Uvinul coated wrappers**

| Type of wrap | Oxidation time |
|---|---|
| | (hours) |
| Light blue control | 12 |
| White control | 12 |
| Dark blue control | 12 |
| Light blue + 0.25% Uvinul | 64 |
| White + 0.25% Uvinul | 64 |
| Dark blue + 0.25% Uvinul | 64 |

## SUMMARY AND CONCLUSIONS

Process cheese in normal cellophane wax-coated wrappers becomes oxidized within twelve hours. This oxidation proceeds to such an extent that within forty-eight hours the top slice becomes inedible. This process can be retarded by incorporating a substituted benzophenone within the wax coating normally applied to certain types of cheese wrappers.

### Acknowledgment

The authors express their thanks to Dr. G. G. Rumberger and his associates at Marathon Corporation, Neenah-Menasha, Wis., for assistance in preparing the wrapping materials used in these experiments.

### LITERATURE CITED

1. Barkworth, H. Taints and off-flavors of milk. *Dairy Inds.* **3**, 367-70, 377 (1938).
2. Barton, H. L. G., and Davies, A. Effectiveness of colored samples of cellophane in retarding the oxidation of olive oil. *J. Soc. Chem. Ind.*, **58**, 189-93 (1939).

3. Berry, W. and Pritchard, F. W. (to British Cellophane Ltd.), Brit. Pat. 573, 236 (Nov. 12, 1945).
4. Biggs, D. A., and Bryant, L. R. The thiobarbituric acid test for butterfat oxidation. *Can. J. Technol.*, **31**, 138-45 (1953).
5. British Cellophane Ltd., Brit Pat. 574, 425 (Jan. 4, 1946).
6. Burciana, L. Action of sunlight on milk. *Biochem. J.*, **31**, 1452-8 (1937).
7. Coe, M. R. Light a factor in rancidity. *Science*, **75**, 585 (1932).
8. Coe, M. R., and Le Clerc, J. A. Photochemical action, a cause of rancidity. *Cereal Chem.*, **9**, 519-22 (1932).
9. Coe, M. R. U. S. Patent 2,418,818 (Apr. 15, 1947).
10. Gluck, B., and Barany, H. C. (to Dufay-Chromex Ltd.), British Patent 591,275 (Aug. 13, 1947).
11. Hood, B. O. Wrapping and packaging butter. *Creamery J.*, **53**(1) 5, 28-30 (1942).
12. Meyer, L. W. A., and Gearhart, W. M. Ultraviolet inhibitors for cellulose-butyrate plastics. *Ind. Eng. Chem.* **43**, 1585-91 (1951).
13. Pearl, I. A. (to Sulphite Products Corp.) U. S. Patent 2,580,461 (Jan. 1, 1952).
14. Riley, E. G. B. (to Rile-Coe Filter Process, Inc.), U. S. Patent 2,631,499 (Mar. 17, 1953).
15. Rumberger, G. G. (to Marathon Corp.) U. S. Patent 2,755,193 (July 17, 1956).
16. Sidwell, C. G., Salwin, H., Benca, M., and Mitchell, J. H., Jr. The use of thiobarbituric acid as measure of fat oxidation. *J. Am. Oil Chemists' Soc.*, **31**, 603-6 (1954).
17. Sternitz, V. C., and Sommer, H. H. The oxidation of butterfat. I. The catalytic effect of light. *J. Dairy Sci.*, **20**, 181-196 (1937).
18. Sternitz, V. C., and Sommer, H. H. The oxidation of butterfat. II. The composition of the fat in relation to its susceptibility toward oxidation. *J. Dairy Sci.*, **20**, 265-80 (1937).
19. Solmar, S. A. R. L. Italian Patent 454,941 (Feb. 8, 1950).
20. Templeton, H. L. and Sommer, H. H. Wrappers for processed cheese. *J. Dairy Sci.*, **20**, 231-8 (1937).
21. Wheelock, C. E. (to Procter and Gamble Co.) U.S. Patent 2,616,855 (Nov. 4, 1952).

# Technological Considerations in the Bulk Transportation of Citrus Juices*

(Manuscript received May 31, 1958)

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One of the basic problems in the processing and distribution of a perishable food product is transportation of the food from point of processing to point of consumption. This problem has been met and solved in many ways in the history of the food processing industry. There will doubtless be many new methods developed and proved satisfactory—methods which today seem only remote possibilities. Transportation of food products is always a problem, but the transportation of a perishable liquid food, particularly in bulk, presents many unique facets.

Within the last several years the production and distribution of chilled citrus juice has become an important part of the gigantic Florida citrus industry. Although this product is not new, it is only recently that the technology of production and transportation has progressed to the point where it could take its place along with the other fine processed citrus products from Florida. Chilled citrus juices are single strength juices extracted from fresh fruit and delivered to the consumer with an absolute minimum of physical processing. As a result of this mild treatment, they are highly perishable, but retain practically all of the natural flavor normally found in freshly extracted juice.

There are many instances where liquid foods, even raw or perishable foods, are moved routinely in bulk containers. Liquid sugar, molasses, beverage syrups and numerous other items are transported daily in a satisfactory manner. Milk is perhaps the most common item of food moved as a bulk liquid. Bulk transportation is now common in all parts of the country. There have been shipments of chilled orange juice made from Florida processing plants to northern points by means of bulk insulated railcars, or insulated tanker trucks.

As would naturally be expected, a highly perishable product such as orange juice requires a constant low temperature during storage and transportation. With our modern insulated, refrigerated truck trailers and refrigerated rail cars the transportation temperature problem has been solved. Although these normal methods of refrigerated transportation are acceptable and reliable, they are also expensive. The economic aspects of this distribution has made the investigation of sea transportation a practical measure.

* Presented before the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Ill., May, 1958.

## SEA TRANSPORTATION

Several years ago, our Company entered the chilled citrus juice business. It became immediately apparent that the cost and availability of proper refrigerated transportation would be a continuing economic problem. It was decided to investigate the possibility of using the cheaper sea transportation as the method of delivering our product to the New York market. To make sea transportation practical a large volume operation must be established and markets developed to consume this large volume of juice. While the markets were being developed, the basic research program was also being developed to determine the feasibility of bulk transportation by sea. Bulk shipment, rather than shipment of the packaged product, would be faster, cheaper, and without the risk of damage to the fiberboard container normally used to package the product.

In bulk methods, a large volume of fluid could be loaded or unloaded by pumps in a fraction of the time it would take stevedores to handle a comparable volume.

## BASIC PROBLEMS

It was immediately obvious that if an ocean-going vessel were to be used in this project several factors would have to be determined. Some of the anticipated problems were architectural or engineering in nature and some were concerned with the technical aspects of how the juice would react under the conditions which would prevail. The basic problems were reduced to these:

1. How *large* can a storage tank be before sanitation and insulation problems become cumbersome, and how *small* can a tank be before it becomes uneconomical?
2. Can a pumping system be devised which will load, unload, and distribute large volumes of juice with no adverse effect on the product (such as aeration, etc.)?
3. In handling large volumes of juice in a single tank, will there be difficulty in pulp separation, temperature stratification, foaming, or any other product deteriorating mechanism?
4. Is there an inert protective coating suitable for the inner lining of metal tanks which may provide a cheaper tank than regular polished stainless steel?
5. Would it be possible to eliminate the sloshing, or tidal effect of a liquid in a tank as the result of the ship's motion?

Many of these considerations were examined in the light of our experience with chilled citrus juices and with the care and sanitation of the large volume equipment used in the manufacture of frozen concentrated orange juice. The palatability of chilled citrus juices is destroyed under normal conditions by 3 factors: microbial fermentation; oxidation; and enzymatic decomposition. There are certain processing techniques which will reduce, retard, or eliminate these 3 processes of deterioration. The "palatable" shelf life of chilled citrus juice is a result of the effectiveness of these processing techniques plus the efficiency of the refrigeration system under which the juice is stored. The actual size of the container, whether it be a quart paper carton or a 100,000 gallon stainless steel tank, is irrelevant if the juice has been treated properly and stored under proper conditions.

With this basic fact in mind, the pertinent question then became not "*can it be done?*" but "*How is it to be done?*" Most of the anticipated problems were due, in their entirety, to the size of the operation. Without exception, these problems were psychological instead of scientific and disappeared as soon as they were placed in their proper perspective.

There were real problems connected with the operation; many of these were concerned with the modification of equipment to handle the anticipated volume and to devise cleaning procedures which would be adequate for the large tanks and equipment.

The vessel selected for conversion to the orange juice tanker was a CIA general cargo freighter. This vessel is 412 feet long and has a displacement of 8,000 tons. It has 5 cargo holds suitable for the installation of insulated tanks. Because of the difference in the size and shape of the cargo holds, each of the tanks is of a different shape and design. They were designed to fit into the respective cargo holds with no structural changes in the ship. Seven tanks were installed in the first conversion, the sizes ranging from 35,000 gallons to 78,000 gallons. Additional tanks were added from time to time as the need for additional volume occurred.

Studies were made of many protective coatings in a search for some product which would be satisfactory for lining the inside of a milled steel tank and thus eliminate the need for a vast amount of stainless steel. Several coatings were found which would impart no flavor to orange juice after prolonged storage, but they would not stand up under the cleaning procedures normally used. Those coatings which would stand the cleaning procedures imparted a detectable taste to the juice after periods of storage.

The studies were initiated by actually constructing the tanks; the next step was lining the inside of a tank with the protective coating under consideration. The tank was then filled with juice and remained in a refrigerated room for 3 weeks or until a flavor developed in the juice. There are several tank linings which are known to be satisfactory for orange juice; they require, however, special application techniques which are impractical in a shipboard application. These were not considered. Such coatings as glass linings and baked phenolics present almost unsurmountable difficulties in the proper curing under field conditions. In the end it was considered best to rely on the more expensive, but reliable stainless steel.

The tanks are of stainless steel with a number four polish on the inside and a pickle finish on the outside. All bracing is external. The tanks are insulated with 6 inches of foamglass. The product is pumped into the bottom of the tank and is removed through the same opening. There is one manhole in each tank to allow the introduction of the cleaning equipment and sani-

tarian. The tanks have a small insulated dome on top and are properly vented. After filling the tanks with product the vents are closed and safety valves for both pressure and vacuum are installed.

## TESTING

After construction and installation of the tanks aboard the ship they were subjected to numerous static tests to determine the effect of various physical conditions. In addition to the hydrostatic tests conducted by the engineering department, the research department made studies to see how the tank was going to react when filled with orange juice. The tanks were filled with refrigerated water and the efficiency of the insulation was checked. Studies were made of the heat transfer through the weight bearing portions of the tanks supports and estimations were made as to the expected gain in temperature each 24 hours.

Under these same conditions the temperature of the water was recorded from the bottom of the tank to the top at intervals of one foot. It was found that with a completely calm tank there was a distinct stratification, or layering, of temperature with the highest temperatures at the bottom of the tank. This was found to be the result of the increased heat transfer at that point, due to the weight-bearing portions of the tank construction—which were made of metal. It was also found that a very minute amount of agitation at certain points within the tank would cause currents, or eddies, within the liquid which would hold the temperature at an even degree throughout.

Studies were made of the swirling effect due to the high velocity during loading and unloading procedures. With a simple baffle arrangement, this condition was corrected and it eliminated any possibility of the incorporation of air at this point. As would be expected, with the absence of air there was no problem with foaming.

To facilitate cleaning, the inner surfaces of the tanks were polished and unbaffled. In ordinary tankers there are many baffles extending down from the top of the tanks which act to prevent the sloshing of the liquid. This sort of baffle would have made tank sanitation more difficult, and so studies were instigated to find methods to prevent sloshing without baffling. From pilot studies it was found that by use of a small raised dome on one end of the tank and by filling the tank while there was a distinct list away from the dome end, the tank could be completely filled. Such a procedure is easily accomplished by loading the after tanks first and thus settling the ship toward the stern.

With all of the air exhausted and the tank completely filled with juice, there was no danger of sloshing and subsequent aeration. This method of filling the tanks also eliminated the need for an elaborate vacuum system aboard ship, although such a system had been originally considered necessary.

## CLEANING

Cleaning procedures established for the pipelines and tanks followed closely the procedures used for years in the cleaning of smaller tanks. All pipelines are cleaned in-place, and the tanks are cleaned by the high pressure circulation of a hot alkaline cleaning solution through revolving nozzles inside the tank. The cleaning procedure is quite simple. It is handled by 2 specially trained sanitarians, who have permanent assignments to the ship for this purpose.

Immediately after the tanks are emptied they are spray rinsed with cold water to remove most of the traces of juice and solids which cling to the wall of the tank. Following this rinse a portable dolly containing a revolving spray head is placed inside the tank and attached to a high pressure hose, through which the hot cleaning solution is pumped. The cleaning solution is heated in a large surge tank and pumped through the revolving nozzles while the dolly is moved in a fore and aft direction. As the solution collects on the floor of the tank, it is returned by the main cargo pump to the surge tank for reheating. This circulation of the hot solution not only cleans the tank but also the main cargo lines and main cargo pump. Following the cleaning solution, the tanks are again rinsed with cold water and one of the sanitarians enters the tank for a visual inspection. This inspection serves to check the efficiency of the in-place cleaning and as a routine check on the physical condition of the inside of the tank. By this method we eliminate the possibility of an undetected tank fracture due to heavy seas. Following this inspection the tank is given a final rinse and sealed for use during the next voyage.

## SUMMING UP

In the evaluation of the cleaning solution and cleaning procedures the tanks were sprayed with a fluorescent material, cleaned, and then examined with an ultra violet light to check the coverage of the high pressure spray. The inner surfaces of the tank and the pipelines were contaminated with a tracer organism and complete bacteriological studies were made of these surfaces after cleaning to determine the bactericidal efficiency of the cleaning solutions and procedures. Every possible variable was taken into consideration in these dockside static studies before cargo was ever risked aboard the vessel.

After careful study of the behavior of the tanks aboard the ship and the correction of the above mentioned items, the first voyage was made in February, 1957. As a result of the careful preparation and study, and the strict observance of the prescribed sanitary precautions, there have been no instances of increased bacteriological counts in the product due to the handling and storage procedures. Samples for bacteriological analysis are taken from the main line to the ship at regular intervals during the loading operation, and from the main discharge line during the unloading operation in New York. At no time have increased bacteriological counts been noted which were greater than those to be expected in orange juice at a given temperature.

# Effect of Radiation on Antibiotic-Treated Meats[a,b,c]

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(Manuscript received May 31, 1958)

INHIBITION of microbial spoilage of fresh red meats has been a major problem in the meat industry. Within recent years antibiotics *(1, 2, 4, 8, 11, 12, 13)* and ionizing radiations *(9, 10)* have each found potential applications in the field of food preservation. Since food spoilage is caused by a number of different bacteria, only the antibiotics with a wide spectrum of activity such as oxytetracycline (OTC) and chlortetracycline (CTC) have been found effective. These antibiotics at the concentrations used in foods are bacteriostatic; ionizing radiations at low (pasteurization) levels reduce the number of organisms present.

Combining these two new techniques and applying them to perishable foods such as meats appear to offer significant advantages in extending storage life. Niven and Chesbro *(7)* showed through antibiotic sensitivity studies that bacteria resistant to irradiation were sensitive to the tetracycline group of antibiotics. They also reported that adding these antibiotics to fresh meats which were subsequently radiated produced a further and significant preservative effect.

The initial series of experiments in this study were investigations of the stability of the tetracyclines at different levels of irradiation; the purpose was to determine whether appreciable antibiotic remained in meat after radiation to offer antibacterial protection during storage. The second series of experiments were undertaken to evaluate the storage life of meats treated with OTC and then radiated at pasteurization dosages. Samples were observed for changes in odor, flavor, and increase in total numbers of viable bacteria. The antibiotic was applied by two methods—antemortem injection and dipping of the meat slices. In previous studies *(3, 6)* antemortem injection resulted in good antibiotic tissue levels because the circulatory system of the animal distributed the antibiotic throughout the body.

## EXPERIMENTAL

**Inactivation of the tetracycline antibiotics by irradiation.** Chlortetracycline hydrochloride, oxytetracycline hydrochloride and tetracycline (TC) hydrochloride were incorporated into ground beef and in distilled water at levels of 5 and 50 p.p.m. (micrograms of antibiotic per gram of sample). Samples were packed into thermal death time cans, frozen, and then shipped to the Materials Testing Reactor (MTR), Arco, Idaho. The cans were irradiated with gamma rays at dosages of 0.18, 0.37, 0.74, 1.48, 2.96 and 4.65 megarads and kept frozen until assayed. Prior to analysis, samples were mixed in phosphate buffer (pH 4.5) and centrifuged. Aliquots of the supernatant were then assayed, using the cylinder plate method and *Bacillus cereus* var. *mycoides* as the test organism *(5)*.

**Radiation of meat treated with oxytetracycline by the antemortem injection procedure.** Biostat[d] solutions were injected by the intrathoracic route into live hogs weighing about 200 pounds each. Levels of 3, 6 and 30 mg. of OTC per pound of live weight were used. Two hours after injection the animals were slaughtered, dressed, and hung overnight at 32° F. Samples of the loins, picnics, and butts from these and control carcasses were wrapped in meat cellophane, packed in No. 10 cans, frozen and irradiated at 0.79 megarad. Shipment of the meats to and from the radiation source (MTR) was under dry ice. Upon arrival at the laboratory, the samples were removed from the cans, stored at 50° F., and observed for changes in appearance and odor to determine their storage life.

**Radiation of oxytetracycline-dipped meats.** Slices of beef were were dipped in a 100 p.p.m. OTC (500 p.p.m. Biostat) water solution; control samples were dipped in distilled water. The samples were dipped for 1 minute and drained for 10 seconds before packaging in poly-mylar-saran film. They were shipped from Corvallis to the MTR and irradiated at 0.1 and 0.3 megarad. Shipment to and from the radiation source was at 32° F. When the samples were returned to the laboratory, they were stored at 34° F. and were examined organoleptically and bacteriologically at regular intervals. Bacteriological counts were conducted by grinding a 10-g. sample in a blender and plating various dilutions on TGY Agar. Plates were incubated at 90° F. and were counted after 48 and 96 hours.

## RESULTS AND DISCUSSION

**Effect of radiation on the residual level of antibiotics.** Stabilities of the 3 antibiotics, CTC, OTC, and TC, when incorporated in meat or water and exposed to ionizing radiations were similar (Tables 1 and 2). The amount of antibiotic added could not be completely recovered from the nonirradiated samples. Thus, the per cent retention in each sample was calculated on the basis of the amount of antibiotic found in the nonirradiated sample. In the meats subjected to pasteurization levels (0.18 to 0.72 megarad) sufficient antibiotic was retained to offer additional protection during storage. At higher dosages, from 0.72 to 1.44 megarads, more than 10% of the antibiotic was retained in meats. At the sterilization level of 4.65 megarads, the antibiotic was completely or almost completely destroyed when it was added at a level of 5 p.p.m. to the meat. It is significant that at both

[a] Technical Paper No. 1125, Oregon Agricultural Experiment Station.

[b] A report of research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, QM Research and Engineering Command, U. S. Army.

[c] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 27, 1958.

[d] Biostat is a food-grade product of Chas. Pfizer & Co., Inc. containing 20% OTC.

# NEW Academic Press Books

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Edited by AARON M. ALTSCHUL, *Southern Regional Research Laboratories, U. S. Department of Agriculture, New Orleans, Louisiana*

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## The Chemistry and Biology of Yeasts

Edited by A. H. COOK, *The Brewing Industry Research Foundation, Nutfield, Surrey, England*

1958, 763 pp., illus., $22.00

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## Toxicology and Applied Pharmacology

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THE PURPOSE OF THE JOURNAL is to bring together in one medium papers dealing with toxicology in a wide range of scientific disciplines. Toxicology in its broad sense includes the effect of chemicals, drugs, pharmaceutical preparations, and natural products on plants, animals, and man. A portion of the JOURNAL will be devoted to contributions which apply the principles of pharmacology to the use of these materials. Investigations which demonstrate no significant toxic effects will be published when of sufficient interest.

The Editors will welcome papers on acute, subacute, and chronic toxicity. Studies to determine the effective, tolerated, and lethal dose of chemicals may be published *per se* or as a part of an extensive investigation. Further, toxicologic data are acceptable which are concerned with the health and welfare of the community, including environmental and industrial toxicology.

The new periodical will be of particular interest to those working in the fields of toxicology, pharmacology, bio-chemistry, nutrition, and veterinary medicine, and to those concerned in the manufacture and use of agricultural chemicals and medicinals, cosmetics, detergents, paints, plastics, lubricants, and fuels. Papers dealing with problems of air and water pollution, irradiation of foods, and of food and feed additives will appeal to a wide audience.

*Manuscripts should be sent to the Managing Editor,* DR. HARRY W. HAYS

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INSIDE SCIENCE

# The Vital Story of VITAMIN A

*by* Science Writer

**We live in a golden age of the sciences!**

In the science of nutrition discoveries of food elements and their action have resulted in the promise of better health for us all.

**Let's consider vitamin A as an example.**

**A Capsule History.** 1913 was the year. Two teams working independently with animal feeding experiments discovered that a diet which was good in all other respects but which varied only in the source of fat caused young animals to thrive or sicken as the fat was varied. The work of these teams (McCollum and Davis; Osborne and Mendel) led to the discovery of the food factor which we know as vitamin A.

**Composition and Action.** A pale yellow, oil-soluble substance, vitamin A is expressed in the chemist's shorthand as $C_{20}H_{29}OH$. It is necessary in the diets of men and animals to promote the body's growth and development. Vitamin A is a vital requirement in guarding the health of the eyes and skin, and for resistance against infection. It helps maintain the health of mucous membranes and other specialized epithelial and glandular tissues.

Vitamin A enters the body as a constituent of food. Or it may be created within the body when a precursor of vitamin A is eaten. A precursor is a food element with potential vitamin A *value* but no actual vitamin A *content*. For instance, many green leaves have a high vitamin A value but, paradoxically, contain no actual vitamin A. The body converts the precursor into the vitamin. The most common precursor of vitamin A is beta carotene, the natural yellow coloring of many foods, such as dairy products, cereal grains, carrots, alfalfa, etc.

When consumed in food vitamin A is absorbed primarily in the healthy intestine, is esterified in the intestine's walls and is carried as an ester in the lymph and blood to the body's storage depots. The liver, which has a large capacity for storage, contains about 90% of the vitamin A found in the body.

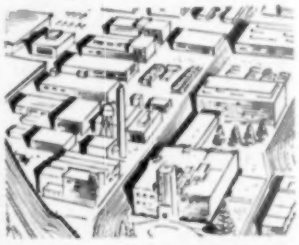
**Isolation and Synthesis.** It was not until 1937 that pure, crystalline vitamin A was isolated by Holmes and Corbett from fish-liver oil. Research in the synthesis of vitamin A was stimulated during the Second World War by the threat to natural sources in fish-liver oil. This work resulted in several processes to produce vitamin A synthetically. Of these, one of the most successful was evolved by the Roche research team headed by Dr. Otto Isler which was announced in 1947. Much of the vitamin A now used for pharmaceutical manufacturing and food fortification in the United States and many other countries of the world is produced by this process.

Vitamin A and beta carotene produced by the Hoffmann-La Roche synthesis have many positive advantages for food and pharmaceutical manufacturers. Among these are the complete absence of any "fishy" odor, taste, or after-taste; the reasonable and stable price; their stability, purity and uniformity and the assurance of a steady economical supply.

Vitamin A is described in the U. S. Pharmacopoeia as a fully acceptable compound for use in pharmaceutical products. The U. S. Food and Drug Administration has approved its use for the fortification of margarine and other foods.

**Human Requirements.** The Food & Nutrition Board of the National Research Council recommends that a daily allowance of 5000 International Units of vitamin A in the diet will maintain good nutrition of healthy adults in the U.S.A. The Board's recommendations vary above this for pregnant and lactating women, and below for infants and children. The adult dose used in therapy may vary from 50,000 to 200,000 units daily.

**Production.** At the huge Roche Park plant of Hoffmann-La Roche in Nutley, New Jersey, over 500 pieces of large-scale chemical engineering equipment are working constantly to produce the superior Roche® vitamin A. This production is so large that Roche vitamin A comes from the plant actually by the tons. In fact, the entire needs of the food and pharmaceutical industries of the United States and Canada can be met from this one plant.



Again the Roche people, who have so often led the way in vitamin research and production, have made another contribution to the better health and well-being of countless millions.

This article is one of a series giving a brief resume of our present knowledge of those essential health factors – the vitamins. Reprints of this and other articles are available without charge. The Vital Story of Vitamin C was published previously and others are forthcoming. Send your request to: Vitamin Division, Hoffmann-La Roche Inc., Nutley 10, N. J. In Canada: Hoffmann-La Roche Ltd., 1956 Bourdon Street, St. Laurent, P. Q.

TABLE 1

**Per cent retention[1] of the tetracyclines in comminuted meat after irradiation (Intial theoretical levels, 5 and 50 p.p.m.)**

| Irradiation | Tetracycline | | Oxytetracycline | | Chlortetracycline | |
|---|---|---|---|---|---|---|
| (megarad) | 5 | 50 | 5 | 50 | 5 | 50 |
| 0 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.18 | 52 | 79 | 80 | 99 | 67 | 82 |
| 0.36 | 46 | 57 | 83 | 102 | 55 | 65 |
| 0.72 | 40 | 36 | 47 | 62 | 22 | 29 |
| 1.44 | 36 | 28 | 38 | 54 | 12 | 15 |
| 2.88 | 31 | 25 | 35 | 25 | <1 | 8 |
| 4.65 | 0 | 13 | trace[2] | 5 | trace | <1 |

[1] Based on the amounts recovered from the nonirradiated sample.
[2] Unmeasurable.

TABLE 2

**Per cent retention[1] of the tetracyclines in aqueous solutions after irradiation (Initial theoretical levels, 5 and 50 p.p.m.)**

| Irradiation | Tetracycline | | Oxytetracycline | | Chlortetracycline | |
|---|---|---|---|---|---|---|
| (megarad) | 5 | 50 | 5 | 50 | 5 | 50 |
| 0 | 100 | 100 | 100 | 100 | 100 | 100 |
| 0.18 | 82 | 84 | 62 | 92 | 67 | 76 |
| 0.36 | 52 | 70 | 86 | 84 | 35 | 106 |
| 0.72 | 36 | 43 | 29 | 58 | 8 | 94 |
| 1.44 | trace[2] | 2 | 0 | 15 | 0 | 3 |
| 2.88 | trace | trace | 0 | <1 | 0 | <1 |
| 4.65 | 0 | <1 | 0 | trace | 0 | trace |

[1] Based on the amounts recovered from the nonirradiated sample.
[2] Unmeasurable.

antibiotic levels used, when dosages higher than 0.72 megarad were employed, the destruction of the antibiotic was considerably higher in water than in meat samples. Thus, meat may offer some protection to the antibiotic when exposed to gamma radiation.

A parallel study with polymyxin, neomycin and oleandomycin indicated that their stabilities under irradiation were similar to those of the tetracycline antibiotics. When the former 3 antibiotics were added to water solutions at levels of 50 p.p.m., a dosage of 0.18 megarad produced no significant destruction in activity whereas a dosage of 5.58 megarads completely or almost completely destroyed their activities.

**Effect of radiation and OTC applied by antemortem injection.** Table 3 presents the mean storage life,

TABLE 3

**Mean number of days of storage life at 50° F. of pork treated with oxytetracycline and/or irradiation**

| Treatment | Mean number days storage life | | | |
|---|---|---|---|---|
| | Loin | Picnic | Butt | Average |
| Control | 2 | 2 | 2 | 2 |
| Oxytetracycline | 5.6 | 3.3 | 2.3 | 3.7 |
| Irradiation (0.79 megarad) | 5 | 5 | 5 | 5 |
| Irradiation plus oxytetracycline | 7 | 8 | 5 | 6.6 |

in days, at 50° F., of meat cuts from hogs which were injected with OTC before slaughter. Radiation produced an average increase in storage life of 150% over the controls. Antibiotic alone produced an average increase of 85% and irradiation combined with the antibiotic treatment caused an increase of 230% as compared with controls. Although radiation produced uniform extensions of shelf life in all cuts of meat studied, with the antibiotic or antibiotic-radiation treatments the extension varied.

Added levels of 3, 6 and 30 mg. of OTC per pound produced concentrations in the meat of about 2, 5 and 8 p.p.m., respectively. There was no appreciable difference in oxytetracycline content of butts, picnics and loins. The 2 higher levels of antibiotic used did not produce an additional extension of storage life beyond that of the lowest level.

**Effect of radiation and OTC applied by dipping.** In Figure 1 the logarithmic number of viable bacteria per gram of meat is plotted against days of storage at 34° F. for 6 groups of meat samples: control, OTC-treated, OCT-treated and radiated at 0.1 megarad, OTC-treated and irradiated at 0.3 megarad, irradiated at 0.1 megarad, and irradiated at 0.3 megarad. Radiation treatment appreciably reduced viable bacteria. The combination of OTC and radiation had a significantly greater effect than either method used alone.

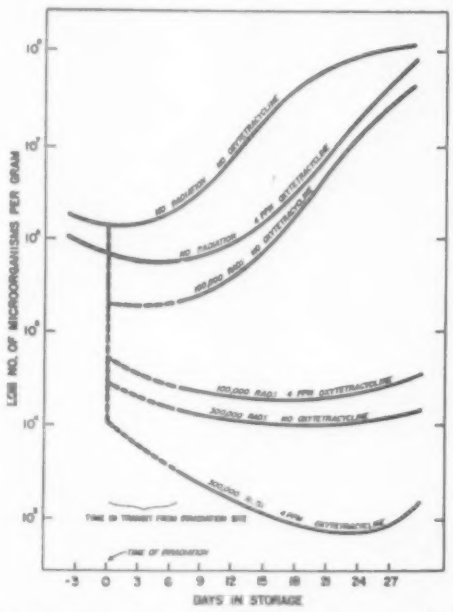



Figure 1. The effect of oxytetracycline and irradiation on the number of organisms in beef stored at 34° F.

The antibiotic concentration in the meat samples averaged about 4 p.p.m. No appreciable inactivation of the antibiotic due to irradiation or storage (up to 32 days) was found. Addition of oxytetracycline resulted in a significant inhibition of bacterial growth. The supplementary effect of the antibiotic was greater when the samples were irradiated at 0.1 than 0.3 megarad. Treatment with OTC plus irradiation at 0.1 megarad resulted in the best sample in terms of odor and color throughout the storage period.

A small flavor panel tasted broiled meat samples for acceptability and found no appreciable differences among the variously treated groups. This finding substantiated results obtained by Niven and Chesbro *(7)*. The panel adversely criticized the flavor of all sam-

ples at the 25th to the 28th day of storage. At that time the mean flavor score of all meat was below the mean acceptability score of the hedonic scale. However, the OTC-radiated (0.1 megarad) sample was still quite palatable after 60 days of storage when given to tasters other than those of the flavor panel. The meat was very tender because of prolonged enzymatic action, a result which is normally desirable. In general, the antibiotic appeared to offer considerable protection not only to odor but also to color, and noticeably diminished the typical irradiation off-odors. Control samples were completely spoiled in 28 days whereas those treated with oxytetracycline and/or irradiation were completely spoiled in about 70 days. Although the OTC-treated and irradiated (0.1 megarad) samples after about 27 to 32 days of storage had a high number of bacteria present, these bacteria did not appear to be responsible for putrefaction and decomposition. The meat spoilage bacteria apparently did not start to develop significantly until after the 50th to the 60th day of storage. Bacteriological data indicated that either treatment alone was appreciably effective and that the combination treatment offers highly significant advantages.

## SUMMARY

At radio-pasteurization dosages (0.18 to 0.72 megarad) the tetracycline antibiotics retained sufficient activity to offer protection to meats during storage. At the sterilization dosage of 4.65 megarads the antibiotics were completely or almost completely destroyed.

Injecting hogs with oxytetracycline before slaughter produced a meat with superior keeping quality when compared with controls. Meat cuts from oxytetracycline-injected animals when exposed to radiopasteurization dosages had more than a three-fold extension in storage life at 50° F.

Cuts dipped in an oxytetracycline solution or irradiated at 0.1 or 0.3 megarad had a significantly lower bacterial count than control samples. The higher radiation dosage resulted in a more significant decrease in bacterial population than the lower dosage.

Maximum reduction of bacteria was obtained in the sample treated with oxytetracycline and irradiated at 0.3 megarad. However, the complementary effect of oxytetracycline in the irradiated sample was more pronounced in the meat irradiated at 0.1 megarad. The combination treatment offered significantly greater protection against bacteria than either treatment alone.

## CONCLUSIONS

From the results obtained it may be postulated that in the commercial distribution of prepackaged fresh meat, meat cuts subjected to antibiotics and radiation would exhibit high keeping qualities. Meats treated with an antibiotic as early as possible would reach the radiation source with a low bacterial count and be superior in quality to an untreated food. Prompt application of an antibiotic would be especially desirable since the radiation sources throughout the country, initially at least, would be limited and considerable time might elapse before a food could be irradiated. Also, in an antibiotic-treated food the radiation dose required to produce a certain preservative effect could be lower and thus, fewer adverse organoleptic changes associated with high levels of irradiation would result. The tetracycline antibiotics would offer additional protection during subsequent storage.

## LITERATURE CITED

1. Ayres, J. C., Walker, H. W., Fanelli, M. J., King, A. W., and Thomas, F. Use of antibiotics in prolonging storage life of dressed chicken. *Food Technol.*, **10**, 563–568 (1956).
2. Carroll, V. J., Benedict, R. A., and Wrenshall, C. L. Delaying vegetable spoilage with antibiotics. *Food Technol.*, **11**, 490–493 (1957).
3. Downing, H. E., McMahan, J. R., and Backer, C. Antibiotic preservation of meats. IV. Intraperitoneal injection of oxytetracycline in hogs. *Antibiotics Ann., 1955/56*, 737–738 (1955).
4. Ginsberg, A., Hill, E. C., and Grieve, J. M. Oxytetracycline and its use as a meat preservative in underdeveloped countries. *Vet. Record*, **69**, 983–993 (1957).
5. Grove, D. C., and Randall, W. A. *Assay Methods of Antibiotics.* Antibiotics Monograph No. 2, Medical Encyclopedia, Inc., New York (1955).
6. McMahan, J. R., Downing, H. E., Ottke, R. C., Luther, H. G., and Wrenshall, C. L. Antibiotic preservation of meats. I. Preliminary experiments with intraperitoneal injection of animals before slaughter. *Antibiotics Ann., 1955/56*, 727–730 (1955).
7. Niven, Jr., C. F., and Chesbro, W. R. Complementary action of antibiotics and irradiation in the preservation of fresh meats. *Antibiotics Ann., 1956/57*, 855–859 (1956).
8. Ordal, Z. J., and Brown, W. L. The effect of oxytetracycline on the keeping quality of cured hams. *Antibiotics Ann., 1956/57*, 860–865 (1956).
9. Proctor, B. E., and Goldblith, S. A. Electromagnetic radiation fundamentals and their applications in food technology. *Advances in Food Research, III*, 119–195, Academic Press Inc., New York (1951).
10. Schultz, H. W., Cain, R. F., and Nordan, H. C. Concomitant use of radiation with other processing methods for meat. *Food Technol.*, **10**, 233–238 (1956).
11. Stern, J. A., Liebman, H. L., Grauer, A. D., Kudo, G., and da Costa, A. A. Comparative studies of the effects of the tetracycline group of antibiotics in the preservation of fish. *Antibiotics Ann., 1956/57*, 984–996 (1956).
12. Weiser, H. H., Goldberg, H. S., Cahill, V. R., Kunkle, L. E., and Deatherage, F. E. Observations on fresh meat processed by the infusion of antibiotics. *Food Technol.*, **7**, 495–499 (1953).
13. Wrenshall, C. L., and McMahan, J. R. How newly ok'd antibiotic boosts poultry shelf-life. *Food Eng.*, **28**, 53–56 (1956).

# Improving Cereals with Defatted Wheat Germ*

(Manuscript received May 31, 1958)

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FOR MANY YEARS plant proteins have been considered by nutritionists to be generally inferior in nutritional value to animal proteins. Early investigators *(3, 22)* found cereals to be poor sources of protein in human and animal nutrition, qualitatively as well as quantitatively. In contrast, the cereal embryos were shown to contain proteins with high nutritive values *(23, 31)*.

It is unfortunate, nutritionally, that the embryo, or the germ of the wheat kernel is removed during the normal milling operation. Although the wheat flour, devoid of the germ, exhibits superior stability and baking qualities *(4, 16)*, it is inferior in nutritive value to whole wheat *(7, 28)*. Table 1 gives the protein values for various foods as calculated from data in the literature *(3, 24)*. Cereal proteins as a whole are shown to be inferior to animal proteins in biological value and protein efficiency ratio (P.E.R.). These are the two most common criteria used in evaluating protein quality *(21, 27)*. Because of the relatively low nitrogen content of plant foods, total protein value (Biological value x digestibility x percent nitrogen) is considerably below that of the animal proteins. Wheat germ, however, is an exception to the rule. The biological value and P.E.R. of wheat germ protein approaches the high values of animal protein. Furthermore, the relatively high nitrogen content of wheat germ combined with its high protein quality places wheat germ in a class with the better animal proteins in total protein value.

It has been established that the poor keeping quality of the wheat germ and of the whole wheat flour is largely due to hydrolytic and oxidative changes in the wheat germ lipids *(16, 29, 30)*. Purified grade raw wheat germ contains approximately 11% oil *(26)*. Nutritionally, it seems reasonable that solvent defatted wheat germ, or flour made with solvent defatted wheat germ can be used to supplement wheat flour, and perhaps other cereals. This would increase their nutritive value without causing a deleterious effect on keeping qualities *(17)*.

The beneficial effect of supplemental wheat germ on the nutritive value of wheat flour has been demonstrated *(6, 8, 19, 33)*. It appears that similar beneficial effects might be produced by supplementing other cereals with defatted wheat germ. Nearly all cereals, including wheat, exhibit lysine as their first limiting amino acid; wheat germ protein is relatively high in lysine. In this work three phases of the nutritive value of defatted wheat germ were investigated by means of a modified Hinners-Scott bio-assay *(12, 13)*:

a) Evaluation of the protein quality of wheat germ.
b) Determination of the effect of various processing methods on the protein quality of wheat germ.
c) Measurement of the effects of the addition of 10 and 15% defatted wheat germ flour on the nutritive value of several cereals.

## EXPERIMENTAL

All experiments were conducted with fast growing chicks of the New Hampshire x Columbian cross. The growing chick is an excellent animal for use in nutritional investigations because of its rapid rate of growth and its high nutrient requirements.

Day-old chicks were placed on an adequate corn-soy pre-test diet containing 3.3% nitrogen for 7 to 14 days preceding the experiment. Before the start of each trial, chicks were individually wing banded and distributed into the experimental lots on the basis of body weight and in a manner to insure that the average starting weight and the variance was equal for all groups. Chicks were placed in thermostatically controlled, electrically heated batteries equipped with raised wire floors. Each experimental diet was fed to a minimum of 2 replicates of 6 to 12 chicks, all of the same sex, allowing 12 to 24 chicks per treatment.

Duration of experiments 1, 2, 3, 5, and 6 was approximately one week, allowing the chicks to consume an average amount of feed equal to their starting weight. Experiment 4 was conducted for almost 2 weeks.

All experimental diets were adequate in the known required vitamins and minerals. The diets contained the following fixed amounts of these nutrients: Corn oil, 10.0 g.; choline chloride, 2.0 g.; thiamine HCl, 100 mg.; niacin, 100 mg.; riboflavin,

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 26, 1958, Chicago, Illinois.

TABLE 1
Protein values of foods

| Protein source | Limiting amino acid | Mitchell's biological value | Protein digestibility | Percent nitrogen | Total protein value | Protein efficiency ratio (P.E.R.) |
|---|---|---|---|---|---|---|
| Oat cereal | Lysine | 66 | 0.93 | 2.7 | 165 | 2.2 |
| Barley cereal | Lysine | 64 | 0.91 | 1.5 | 87 | 1.8 |
| Rice cereal | Lysine | 66 | 0.78 | 1.1 | 57 | 1.9 |
| Whole corn | Lysine | 60 | 0.94 | 1.5 | 84 | 1.2 |
| Wheat flour | Lysine | 52 | 1.00 | 1.9 | 100 | 1.0 |
| Whole wheat | Lysine | 70 | 0.91 | 2.2 | 140 | 1.5 |
| Dried beef | Methionine | 76 | 1.00 | 11.3 | 860 | 3.2 |
| Dried egg | ..... | 94 | 1.00 | 7.8 | 730 | 3.8 |
| Dried milk | Methionine | 90 | 0.95 | 4.0 | 340 | 2.9 |
| Defatted wheat germ | Isoleucine | 75 | 0.95 | 5.5 | 390 | 2.9 |

16 mg.; Ca pantothenate, 20 mg.; vitamin $B_{12}$, 0.02 mg.; p-amino benzoic acid, 2 mg.; menadione, 5 mg.; ascorbic acid, 250 mg.; alpha-tocopherol acetate, 20 mg.; vitamin A acetate, 10,000 I.U.; vitamin $D_3$, 600 I.C.U.; NaCl, 8.8 g.; Fe $(C_6H_5O_7)_2 \cdot 6H_2O$, 1.4 g.; $MgSO_4 \cdot 7H_2O$, 2.5 g.; $K_2HPO_4$, 9.0 g.; $CaCO_3$, 3.0 g.; $Ca_3(PO_4)_2$, 28.0 g.; $MnSO_4 \cdot H_2O$, 650 mg.; $ZnCl_2$, 20 mg.; $CuSO_4 \cdot 5H_2O$, 20 mg.; KI, 40 mg.; $H_3BO_3$, 9 mg.; $CoSo_4 \cdot 7H_2O$, 1 mg.

A complete salt mix was used, along with corn oil (providing essential fatty acids), and all vitamins known to be required by the growing chick *(1)*. The only variable nutrients were the protein source which usually supplied 1.6% nitrogen in the diet, and the amount of glucose monohydrate (cerelose) which was used as the main source of food energy.

In experiments 1, 2, 3, and 4 all diets contained 1.6% nitrogen, equivalent to 10% "crude protein" (N x 6.25). This protein content was considerably below the required level for the young growing chick, but was intentionally used in order to accentuate the differences in the quality of proteins which were fed *(12)*. Feed and water were fed *ad libitum*. Animals were individually weighed at intervals of 2 to 3 days and their weight gain and feed intake were recorded per each replicate of 6 to 12 chicks. Interpolation of growth curves against feed intake was made to obtain the corresponding weight gain made on a given intake of feed. These "equalized" gains were used along with the *ad libitum* gains and the P.E.R. values (gram gain per gram protein consumed) in the interpretation of the results.

In experiments 5 and 6, no attempt was made to control the protein content of the diets. Instead, the cereal, or the cereal supplemented with defatted wheat germ, made up 65% of the total diets.

Results were subjected to statistical treatment using the analysis of variance technique. The Least Significant Range (LSR) was determined with the method outlined by Duncan *(9)*.

## RESULTS AND DISCUSSION

Results of experiment 1 are shown in Table 2. This was the standard protein quality assay, in which VioBin defatted high quality fish meal served as a positive standard, and isolated soy protein [Drackett Assay Protein (C-1)] served as a negative standard. As a sole source of dietary protein, the fish flour had an index value of 135 versus a value of 100 for the soy protein, based on "equalized" weight gains over a protein free diet.

**TABLE 2**

**Evaluation of the protein quality of wheat germ—(exp. 1)**

| Protein source | Gain [a] | Index |
|---|---|---|
| | *grams* | |
| 1. VioBin fish flour | 393 | 135 |
| 2. Isolated soy protein (Drackett C-1) | 290 | 100 |
| 3. Soy flour | 368 | 127 |
| 4. Solvent defatted wheat germ | 396 | 136 |
| 5. Isolated wheat germ protein | 369 | 127 |
| L.S.R. (p = 5%) | 16 | |

[a] "Equalized" gain over protein-free diet.

The defatted wheat germ sample was made by solvent extraction of a purified grade of wheat germ which was kept in cold storage prior to extraction in the VioBin plant. When this mildly steamed, defatted wheat germ was fed as a sole source of protein, it had an index value of 136, equal to the fish flour. Isolated wheat germ protein, a product prepared from defatted wheat germ by extraction with dilute KOH solution and precipitation at the isoelectric point, had a slightly lower index value, 127, comparable to the value of soy flour (solvent extracted soybean oil meal). Note that the defatted wheat germ sample contained 5.5% nitrogen, and the isolated wheat germ protein contained 14.0% nitrogen.

The isolated proteins from wheat germ and soybean had a lower protein quality index value than their respective parent material. Yet, one must be impressed by the high protein quality of both defatted wheat germ and its soluble protein fraction as measured by the chick bio-assay. This is particularly striking since high quality fish meal was shown to be slightly superior to egg white as a sole source of protein in the chick diet *(12)*. This confirms the findings of other workers who have demonstrated the high protein quality of wheat germ when fed as a sole source of protein to other experimental animals *(14, 31, 32)*. Isolated wheat germ protein was shown to be superior to casein as a sole nitrogen source for the depleted rat *(18)*.

Effects of several processing methods on the protein quality of defatted wheat germ are shown in Table 3. Four wheat germ samples were compared with the standard fish flour and the Drackett soy protein. It is apparent that mild steaming and light toasting [b] improved the protein quality of the defatted wheat germ as shown by the weight gains. All wheat germ samples were superior to soy protein in supporting chick growth, but only the mildly heated samples were equal to fish flour in growth promoting ability. Mild heating also tended to improve slightly the protein efficiency ratio of defatted wheat germ, but by this criterion, none of the wheat germ samples could equal the performance of fish flour. Although improvement in the nutritive value of defatted wheat germ due to mild steaming and light toasting was unexpected, it was not entirely surprising. Other plant proteins have been shown to improve in digestibility and biological value due to heat treatment *(2, 11)*. Excessive heating, as would be expected, has been shown to produce adverse effects on the nutritive value of either plant or animal proteins *(5, 10, 20, 25)*.

**TABLE 3**

**Effect of mild heating on protein quality of wheat germ—(exp. 2)**

| Protein source | Gain [a] | Protein efficiency ratio |
|---|---|---|
| | *grams* | |
| 1. Defatted raw wheat germ | 186 | 4.7 |
| 2. As (1)—laboratory steamed | 209 | 4.8 |
| 3. As (1)—plant steamed | 202 | 4.8 |
| 4. As (1)—light toasted | 214 | 4.8 |
| 5. Isolated soy protein (Drackett C-1) | 142 | 3.4 |
| 6. VioBin fish flour | 204 | 5.0 |
| L.S.R. (p = 5%) | 20 | |

[a] *Ad libitum* gain.

[b] The term "light toasting" as used in this paper is not a general term, but refers specifically to the detection of a standard color change that takes place when defatted wheat germ is dry heated. Mild steaming is referred to the application of open steam at atmospheric pressure for 20 minutes.

TABLE 4

Effect of processing on protein quality of wheat germ—(Exp. 3 and 4)

| Protein source | Experiment 3 Gain (grams) | | Experiment 4 Gain (grams) |
|---|---|---|---|
| | Ad libitum | Equalized | Ad libitum |
| | *grams* | | *grams* |
| 1. Solvent defatted wheat germ (VioBin) steamed | 230 | 160 | 428 |
| 2. Solvent defatted wheat germ, light toasted | ..... | ..... | 411 |
| 3. Pressed defatted wheat germ, steamed | 78 | 81 | 248 |
| 4. VioBin fish flour | 241 | 176 | 440 |
| L.S.R. (p = 5%) | 18 | | 35 |

This is also shown in Table 4, in which a pressed wheat germ sample appeared to be relatively poor in its protein quality.

This wheat germ sample, purchased as a by-product from the wheat germ oil pressing process,[c] still contained 5% fat which was extracted prior to the feeding trial. It was suspected of having been excessively heated in processing, since its extracted residual oil was shown to drop 10 points in the iodine number, indicating considerable polymerization and autoxidation damage *(15)*. The assay (experiment 3) showed that pressed defatted wheat germ was significantly inferior in its growth promoting ability to the solvent defatted (VioBin) wheat germ. A similar experiment (No. 4) was conducted for a longer period (2 weeks); the results were substantially the same (Table 4). In this assay both the steamed and light toasted solvent defatted wheat germ were statistically equal (though slightly lower) to the protein quality of the fish flour. However, the pressed wheat germ sample was significantly inferior in its protein quality. This indicates that a severe heat treatment, which may have developed in expelling, may produce deleterious effects on the nutritive value of the wheat germ.

Effects of supplementing various cereals with 10% defatted wheat germ flour are shown in Table 5. Diets in this experiment varied in nitrogen content depending on the specific cereal,[d] which comprised 65% of the total diet. The results represent a comparison in the protein quality. As single cereals, oats (2.78%N), barley (1.48%N), rice (1.13%N), and enriched wheat flour (1.94%N) were found to be in decreasing order in ability to support chick growth. Note that enriched wheat flour revealed the poorest performance although it was second only to the oat cereal in nitrogen content. This emphasized the low protein quality of the enriched wheat flour. When 10% defatted wheat germ flour (light toasted) was added to these cereals, the response in chick gain was striking. An improvement of 46% was observed with 10% defatted wheat germ (D.W.G.F.) supplementation to the rice, the barley, the oats, and to the mixture of equal parts of these cereals was 34, 27, 13 and 18%, respectively.

In spite of these significant improvements, neither of the cereals alone, nor cereals supplemented with 10% defatted wheat germ flour, could approach the performance shown by the diet containing 65% defatted wheat germ.

Table 6 further demonstrates the nutritional improvement shown by the addition of 15% light toasted defatted wheat germ flour to these cereals. The reported gains are given for both *ad libitum* and "equalized" feed intake. The performance of the individual cereals remained in the same order as shown in experiment 5. The improvements due to the D.W.G. supplementations were calculated on the basis of the "equalized" gains. These were 69%, 69%, 56%, and 31% for the enriched wheat flour, rice cereal, barley cereal, and oat cereal, respectively.

[c] This sample may not have been typical of a pressed wheat germ. It is used to demonstrate that an uncontrolled processing method may lower the nutritive value of the wheat germ.

[d] The cereals were purchased on the open market as rolled oats, pearled barley, polished rice and all purpose wheat flour.

TABLE 5

The improvement of cereals with defatted wheat germ flour (D.W.G.F.)—(Exp. 5)

| Protein source | Gain [1] | D.W.G.F. increase |
|---|---|---|
| | *grams* | |
| 1. Wheat flour | 107 | |
| 2. (1) + 10% D.W.G.F. | 157 | 46% |
| 3. Rice cereal | 138 | |
| 4. (3) + 10% D.W.G.F. | 185 | 34% |
| 5. Barley cereal | 159 | |
| 6. (5) + 10% D.W.G.F. | 202 | 27% |
| 7. Oat cereal | 221 | |
| 8. (7) + 10% D.W.G.F. | 248 | 13% |
| 9. Cereal mixture | 128 | |
| 10. (9) + 10% D.W.G.F. | 151 | 18% |
| 11. Defatted wheat germ flour | 396 | |

[1] *Ad libitum* gain.

TABLE 6

The improvement of cereals with defatted wheat germ flour (D.W.G.F.)—(Exp. 6)

| Protein source | Gain (grams) | | D.W.G.F. increase |
|---|---|---|---|
| | Ad libitum | Equalized | |
| 1. Wheat flour | 116 | 120 | |
| 2. (1) + 15% D.W.G.F. | 228 | 202 | 69% |
| 3. Rice cereal | 154 | 139 | |
| 4. (3) + 15% D.W.G.F. | 297 | 236 | 69% |
| 5. Barley cereal | 181 | 161 | |
| 6. (5) + 15% D.W.G.F. | 303 | 252 | 56% |
| 7. Oat cereal | 362 | 281 | |
| 8. (7) + 15% D.W.G.F. | 480 | 369 | 31% |
| 9. Defatted wheat germ flour | 721 | 463 | |

Chick gain performance shown with the diet containing the oat cereal supplemented with 15% D.W.G. came nearest to the gain performance shown with the defatted wheat germ diet, but was still considerably inferior to the latter.

Data in experiments 5 and 6 were combined; they appear in histogram form in Figure 1. Performance of the enriched wheat flour diet was taken as a control with an index of 100. The other cereals were then compared with the enriched wheat flour as sole sources of dietary protein. These cereals supplemented with 10% and 15% defatted wheat germ flour were also compared. The beneficial effect of the defatted wheat germ supplementation was clearly demonstrated. Thus, enriched wheat flour, supplemented with 15% defatted wheat germ was shown to be nutritionally superior to either rice or barley. The protein value of

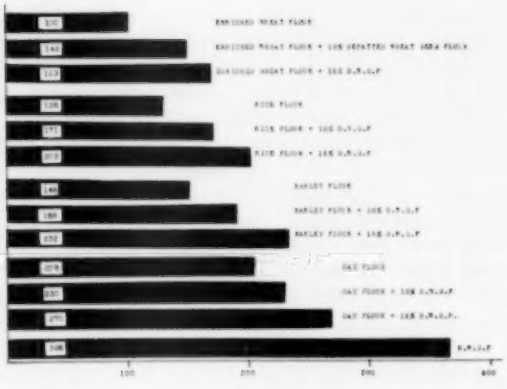


**Figure 1. The nutritional improvement of cereals with defatted wheat germ flour.**

oat flour was exceeded by barley supplemented with 15% defatted wheat germ. These figures indicate to the food technologist that the nutritive value of breakfast cereals and of other food cereals, commonly used for human consumption, can be greatly enhanced by the addition of small amounts of defatted wheat germ.

## SUMMARY

A modification of the Hinners-Scott bio-assay was used to measure the nutritive value of defatted wheat germ and of cereals supplemented with defatted wheat germ.

The protein quality of defatted wheat germ was shown to compare favorably with high quality defatted fish meal.

Mild heat treatments, such as steaming and light toasting, were shown to have enhanced the protein quality of defatted wheat germ.

As single cereals, the nutritive values of oats, barley, rice, and enriched wheat flour were found to be in a decreasing order.

Supplementing cereals with 10 and 15% defatted wheat germ produced striking improvements in the nutritive value of enriched wheat flour, rice, barley, oats, and a mixture of these cereals.

### Acknowledgment

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## LITERATURE CITED

1. Anonymous. Nutrient requirements for poultry. National Research Council Publication, 301 (1954).
2. Barnes, R. H., and Maack, J. E. Review of the literature on the nutritive value of soybeans. The Hormel Institute, Univ. Minnesota (1944).
3. Block, R. J., and Mitchell, H. H. The correlation of the amino acid composition of proteins with their nutritive value. *Nutr. Abstr. and Rev.*, **16**, 249 (1946).
4. Bull, J. E. An investigation of the cause of degrading effect of wheat germ on the baking quality of flour. *Cereal Chem.*, **14**, 244 (1937).
5. Cannon, Paul, and Associates. The problem of heat injury to dietary protein. Report of the committee on protein foods. Food and Nutrition Board, Natl. Research Council Reprint and Cir. Ser. No. 131 (1950).
6. Cerquiglini, S. The nutrient value of bread containing wheat germ. *Quaderni Nutriz*, **5**, 355 (1938).
7. Chick, H. Biological value of the proteins contained in wheat flours. *Lancet*, 405 (1942).
8. Chick, H., Boas-Fixen, M. A., Hutchison, J. C. D., and Jackson, H. M. The biological value of proteins. VII. The influences of variation in the level of protein in the diet and of heating the protein on its biological value. *Biochem. J.*, **29**, 1712 (1935).
9. Duncan, D. B. Multiple range and multiple F tests. *Biometrics*, **11**, 1 (1955).
10. Frazier, I. E., Cannon, P. R., and Hughes, R. H. The problem of heat injury to dietary protein. *Food Research*, **18**, 91 (1953).
11. Gray, J. A., Hill, D. C., and Branion, H. D. Effect of heat on the lysine content of rapeseed. *Poultry Sci.*, **36**, 1193 (1957).
12. Hinners, S. W. A bio-assay for determining the nutritional adequacy of protein supplements for chick growth. Doctoral thesis, University of Illinois (1958).
13. Hinners, S. W., and Scott, H. M. A bio-assay for determining the nutritional adequacy of protein supplements for chick growth. *Poultry Sci.*, **36**, 1126 (1957).
14. Hove, E. L., and Harrel, C. G. Nutritive value of wheat germ protein. *Cereal Chem.*, **20**, 141 (1943).
15. Johnson, O. C., and Kummerow, F. A. Chemical changes which take place in an edible oil during thermal oxidation. *J. Am. Oil Chemists' Soc.*, **34**, 407 (1957).
16. Kuhl, H. The action of cereal fat and free fat acids on the baking capacity of flour with special reference to storage. *Mehl u. Brot*, **41**, 297 (1941).
17. Levin, E. Method of treating cereal germ grain. U. S. Patent 2,314,282, Mar. 16, 1943.
18. Levin, E., and Ershoff, B. Evaluation of isolated wheat germ protein by the rat repletion method. (Unpublished data).
19. McHenry, E. W. Observations on the nutritive value of bread. *Can. Pub. Health J.*, **31**, 428 (1940).
20. Melnick, D., and Oser, B. L. The influence of heat processing on the functional and nutritive properties of protein. *Food Technol.*, **3**, 57 (1949).
21. Mitchell, H. H. A method of determining the biological value of protein. *J. Biol. Chem.*, **58**, 873 (1924).
22. Mitchell, H. H. The protein value of foods in nutrition. *J. Home Econ.*, **19**, 122 (1927).
23. Mitchell, H. H., and Beadles, J. R. Corn Germ: A valuable protein food. *Science*, **99**, 129 (1944).
24. Mitchell, H. H., and Block, R. J. Some relationships between the amino acid contents of proteins and their nutritive values for the rat. *J. Biol. Chem.*, **163**, 599 (1946).
25. Morgan, A. F. The effect of heat upon the biological value of cereal proteins and casein. *J. Biol. Chem.*, **90**, 771 (1931).
26. Osborne, T. B., and Mendel, L. B. Analysis of commercial wheat germ. *J. Biol. Chem.*, **31**, 557 (1919).
27. Osborne, T. B., Mendel, L. B., and Ferry, E. L. A method expressing numerically the growth promoting value of proteins. *J. Biol. Chem.*, **37**, 223 (1919).
28. Osborne, T. B., and Mendel, L. B. The nutritive value of the wheat kernel and its milling products. *J. Biol. Chem.*, **37**, 557 (1919).

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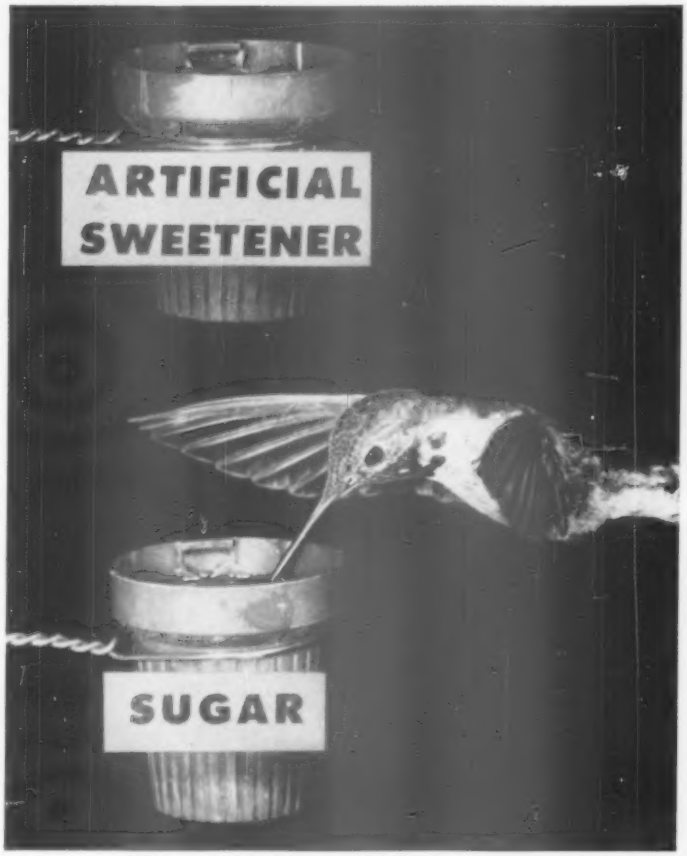


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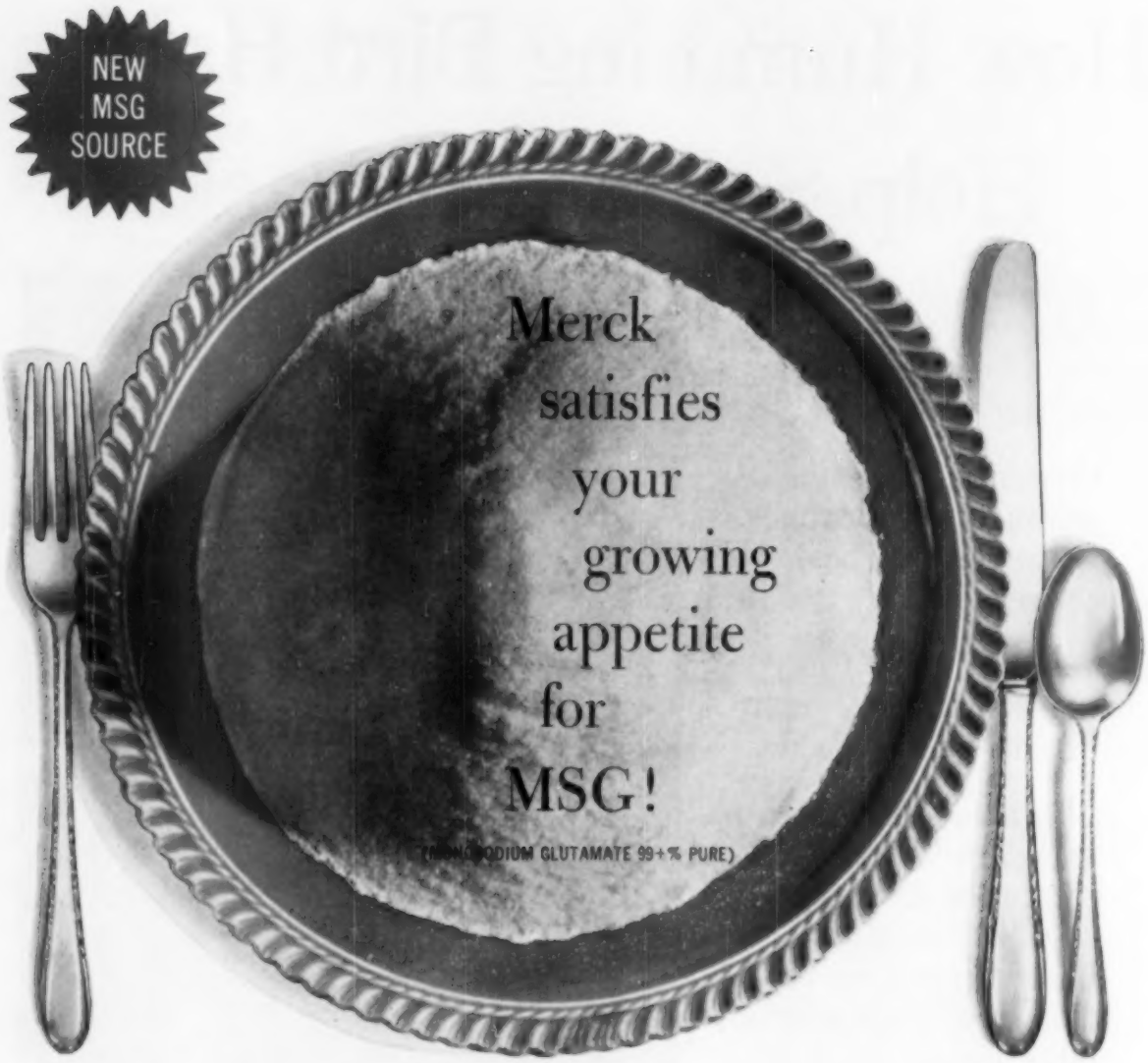


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29. Sherwood, R. C., Andrews, J. S., Wade, W. B., and Bailey, C. H. The march of acidity in wheat germ during storage. *Ind. Eng. Chem.*, **25**, 437 (1933).

30. Sinclair, A. T., and McCalla, A. G. The influence of lipoids on the quality and keeping properties of flour. *Can. J. Research*, **15C**, 187 (1937).

31. Stare, E. J., and Hegsted, D. M. Nutritive value of wheat germ, corn germ and oat proteins. *Federation Proc.*, **3**, 120 (1944).

32. Sure, B. Relative nutritive values of proteins in various foods at increasingly high levels of protein intake. *J. Agr. Food Chem.*, **5**, 463 (1957).

33. Westerman, B. D., Oliver, B., and May, E. Improving the nutritive value of flour. VI. A comparison of the use of soya flour and wheat germ. *J. Nutrition*, **54**, 225 (1954).

# Antioxidant Treatment of Paperboard for Increased Shelf Life of Packaged Dry Cereals*

**E. F. Caldwell and Sylvia Shmigelsky**

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(Manuscript received May 31, 1958)

Effectiveness of phenolic antioxidants in preserving food fats and the food products made from them has been well established for many years *(1)*. More recently these antioxidants have also been advocated for application to packaging materials *(2, 3, 6)*. Paperboard is high in trace metals such as copper and iron, especially if it is made from reworked material *(7)*. These elements are known to catalyze the atmospheric oxidation of fat. Small quantities of fat contact them by being absorbed into the board from the food product, a process which at the same time increases the effective surface area of fat exposed to atmospheric oxygen.

One obvious way to head off this process and extend shelf life is to prevent the fat from reaching the board by means of a grease-proof coating or liner. This approach has been quite generally followed with certain dry baked products such as soda crackers, where the fat content is high enough to stain paperboard. It is not completely effective and has not generally been considered worthwhile for cereals because of the small amounts of fat they contain.

Another approach is to incorporate an antioxidant in or on paperboard or other packaging material to prevent fat oxidation in at least one place where it probably would otherwise occur. Experimental proof of the effectiveness of such a treatment has generally rested on the results of accelerated storage tests of treated and untreated material smeared with lard *(3)*, or of baked products such as cookies *(1)* packaged in treated versus untreated board. In the study now reported the stabilizing effect of antioxidant treatment of paperboard has been shown to extend to certain dry cereals even though their fat contents are very low. The cereals were packaged under mill conditions in commercially-treated board. Appropriate controls were present, and after accelerated storage all products were evaluated organoleptically under carefully controlled conditions by a group of non-expert judges using the hedonic rating scale system.

## MATERIALS AND METHODS

**Paperboard treatment.** Double-bleached manila-lined chipboard was treated by the board manufacturer with butylated hydroxyanisole prior to being made into one-ounce individual cereal packages. The antioxidant was applied to the inside surface of the board in an amount equal to 0.05% of the board by weight. This was accomplished by spraying a 25% oil solution of butylated hydroxyanisole emulsified in water onto the back of the sheet as it passed through a rotary printing press.

**Packaging and storage.** Three types of flaked dry cereal were packaged in this material, each individual package being overwrapped with 300 MST Cellophane. Control packages of untreated board were also prepared. Neither package was printed on the outside. Shelf life tests were conducted at room temperature and at 100° F., with ambient humidity in each case.

**Panel evaluation.** Organoleptic evaluations for aroma, flavor, and over-all acceptability were made after the packaged products had been in storage at 100° F. for 18 weeks and 52 weeks, and at room temperature for 52 weeks. All tests were conducted under controlled conditions, using the same procedure. Panels of between 24 and 35 non-expert judges were selected at random from the laboratory staff. The judges had no previous knowledge of the test problem; they were told only the type of cereal to be judged. All packages were coded using a random lettering system.

At the time of testing, each judge was given an unopened treated package of cereal and an untreated control package of the same cereal. After the transparent overwrap had been broken, each sample was evaluated for the 3 characteristics on a 9-point hedonic rating scale, using the form illustrated in Figure 1. No milk or other food was used in any test, but the judges were allowed to sip water between samples.

* Presented at the Eighteenth Annual Meeting, Institute of Food Technologists, Chicago, Ill., May 28, 1958.

**THE QUAKER OATS COMPANY**

Signature_____ Date_____

Opposite the sample number please check the degree of pleasantness or unpleasantness of each sample for the properties under consideration in this test.

SAMPLE NO._____

| Characteristic | Extremely pleasing | Very pleasing | Moderately pleasing | Slightly pleasing | Neither pleasing nor displeasing | Slightly displeasing | Moderately displeasing | Very displeasing | Extremely displeasing |
|---|---|---|---|---|---|---|---|---|---|
| Aroma | | | | | | | | | |
| Flavor | | | | | | | | | |
| Over-all Acceptability | | | | | | | | | |

SAMPLE NO._____

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Aroma | | | | | | | | | |
| Flavor | | | | | | | | | |
| Over-all Acceptability | | | | | | | | | |

SAMPLE NO._____

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Aroma | | | | | | | | | |
| Flavor | | | | | | | | | |
| Over-all Acceptability | | | | | | | | | |

**Figure 1. Test form used in evaluating samples on the hedonic rating scale.**

Statistical analysis was based on the technique described by Peryam and Girardot *(5)* whereby the verbal designations of the 9-point hedonic rating scale are assigned numbers, in this case ranging from −4 (extremely displeasing) to +4 (extremely pleasing). This is illustrated in Figure 2. Mean ratings were calculated for each characteristic of each product and subjected to analysis of variance in order to test the significance of any differences observed.

## RESULTS

Results of the storage test at room temperature are given in Figure 3. In this graphical presentation all differences not

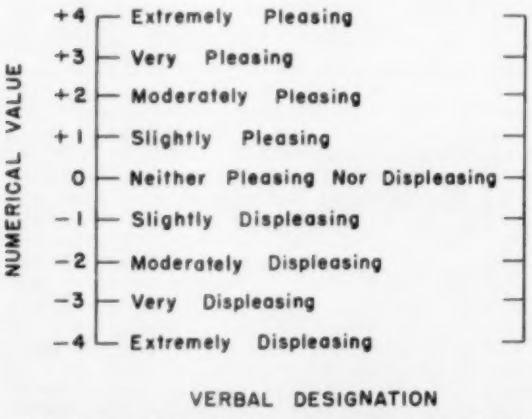


**Figure 2. Relationship between numerical and verbal designations of the hedonic rating scale.**

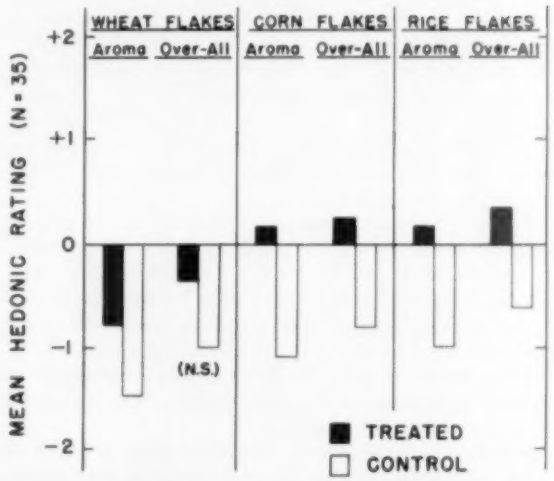


**Figure 3. Effect of antioxidant treatment of paperboard on the mean hedonic rating of 3 cereals after storage at room temperature for 52 weeks.**

statistically significant at the 5% level or better are marked "N.S." All cereals kept in the antioxidant-treated package material were improved in acceptability over the corresponding controls. Mean flavor ratings closely paralleled those for aroma and overall preference and consequently were omitted in the interests of conciseness.

Results of the accelerated storage test at 100° F. are given in Figures 4 and 5. Here it may be seen that the board treatment is beneficial to wheat flakes and corn flakes on the basis

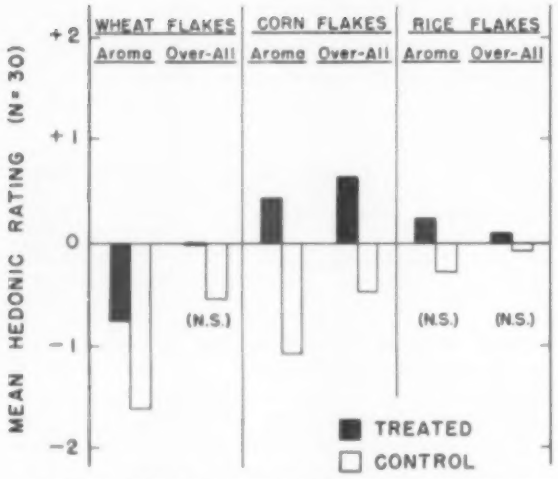


Figure 4. Effect of antioxidant treatment of paperboard on the mean hedonic rating of 3 cereals after storage at 100° F. for 18 weeks.

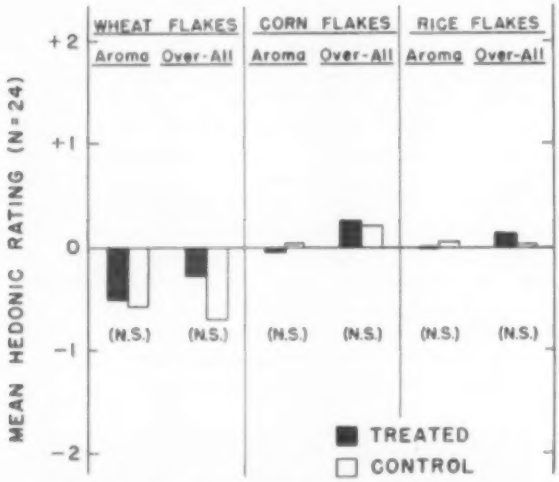


Figure 5. Effect of antioxidant treatment of paperboard on the mean hedonic rating of 3 cereals after storage at 100° F. for 52 weeks.

of an 18-week test, although its antioxidant effect was lost after prolonged storage at the elevated temperature.

## DISCUSSION

Results of this study clearly demonstrate that application of an antioxidant to the package material can improve the storage stability of flake cereals despite their low fat content. This improvement is particularly apparent in wheat and corn flakes during the early months of shelf life. The relatively low mean ratings obtained for all samples may be attributed to the absence from the test program of milk and sugar or other foods commonly eaten with cereals.

While the antioxidant chemical used in this study was butylated hydroxyanisole, subsequent developments *(1, 3)* have indicated that butylated hydroxytoluene, which is cheaper as well as being essentially odorless and tasteless, may be equally effective. Similarly, use of a roll application on the dry sheet of paperboard as it leaves the paper machine *(2, 3)* would appear to have certain advantages as compared with the spray method described earlier.

## SUMMARY

Double-bleached manila-lined chipboard was treated by the board manufacturer with butylated hydroxyanisole prior to being made into one-ounce individual cereal packages. The antioxidant was applied to the inside surface of the board in an amount equal to 0.05% of the board by weight. Three types of flaked dry cereal were packaged in this material, each package being overwrapped with 300 MST Cellophane. Shelf life tests were conducted at room temperature and at 100° F. Control packages of untreated board were prepared and included in these tests. Panel evaluations of aroma, flavor and overall preference were conducted after 18 weeks and 52 weeks with groups of non-expert judges using the hedonic rating system. Antioxidant treatment of the paperboard was found to result in a significant improvement in acceptability after storage in all three cereals.

### Acknowledgments

The authors express their thanks to Dr. James J. Harrison of Michigan Carton Co., Battle Creek, Mich. for supplying the carton blanks used in this study, and to Dr. Ben Stuckey of Eastman Chemical Products, Inc., Kingsport, Tenn. for helpful suggestions concerning the use of antioxidants.

## LITERATURE CITED

1. Anonymous. Antioxidant food board. *Modern Packaging*, 29, (5) 118–119, 202, 204 (1956).
2. Bentz, R. W. Antioxidants for food papers. *Modern Packaging*, 27, (1) 141–145 (1953).
3. Doyle, M. E., Sullivan, R. D., and Booth, H. G. Use of antioxidant in paper board. *Modern Packaging*, 29, (11) 119–123, 195 (1956).
4. Gearhart, W. M., and Stuckey, B. N. A comparison of commercially used phenolic antioxidants in edible animal fats. *J. Am. Oil Chem. Soc.*, 32, 386–390 (1955).
5. Peryam, D. R., and Girardot, N. F. Advanced taste-test method. *Food Eng.*, 24, (7) 58–61, 194 (1952).
6. Stuckey, B. N. Increasing shelf life of cereals with phenolic antioxidants. *Food Technol.*, 9, 585–587 (1955).
7. Thompson, J. B., and Kocher, R. B. Trace metals in food packaging. *Modern Packaging*, 23, (9) 119–122 (1950).

# An Instrument Using Light Transmittance for Nondestructive Measurement of Fruit Maturity*

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(Manuscript received May 31, 1958)

MATURITY IS ONE of the most difficult quality factors to evaluate in agricultural products. Many methods of evaluation have been proposed and some of these are in general use. Most of these methods involve destructive tests. Reliable nondestructive tests for many commodities are much desired. Color has long been recognized as a good maturity index with either ground color of the skin or flesh color being used. The skin color can be evaluated by reflectance measurements without damaging the sample, but until very recently no method has been proposed for nondestructive evaluation of flesh color.

Norris in 1956 *(3)* suggested that light transmittance measurements could be used to indicate the flesh color of an intact fruit. Birth, Norris, and Yeatman reported in 1957 *(1)* on such a measurement for tomatoes. These authors suggested a ratio measurement for indicating interior color. They also suggested using the wavelength of peak transmittance for indicating ripeness of tomatoes. Instrumentation for measuring the spectral transmittance of agricultural commodities was described in 1957 *(4)*. Results obtained by using the ratio of light transmitted at 700 mμ relative to that at 740 mμ to indicate the stage of maturation of peaches from one tree were included in this report.

Exploratory investigations on other fruit indicated that the wavelength of peak transmittance criterion might be applicable in evaluating the stage of maturation of several types of deciduous fruit. This measurement was equally accurate in evaluating the stage of maturation of green fruit as well as fully colored yellow or red fruit. These considerations suggested that this criterion for determining the stage of maturation of fruit justified further development.

The wavelength of peak transmittance through a homogenous sample can be compared to the measurement of Dominant Wavelength by reflectance techniques, although the total ranges of the two may be different *(2)*. Therefore, the wavelength of peak transmittance should indicate the internal color or flesh color of the sample. In an actual sample that has a skin color different from the flesh, the volume of flesh is much greater than the volume of skin; it is therefore reasonable that a transmittance measurement would express the color of the flesh and not the skin color. In practice this is found to be the case; i.e., the skin color of apples has little or no effect on the transmittance measurement. This transmittance measurement may also be considered on the basis of the pigments present in the sample. If there were no pigments present, the transmittance curve would show no peaks as the visible spectrum is scanned. The presence of chlorophyll introduces very strong absorptions at 670 mμ and 430 mμ. Therefore, the presence of this pigment alone would cause the wavelength of peak transmittance to occur in the region from 450 to 650 mμ. The presence of any yellow or red pigments would cause absorptions in the 400 to 600 mμ region and would thus shift the wavelength of peak transmittance to longer wavelengths. From this it is apparent that a green fruit will have a peak transmittance in the 550 mμ region and this peak will shift to longer wavelengths as the yellow and red pigments increase and chlorophyll content decreases. This is the natural physiological change which occurs as a fruit matures so it is to be expected that the wavelength of peak transmittance will correlate with the stage of maturation of the fruit. An instrument developed to employ this principle of measuring maturity is shown in Figure 1. The instrument has been termed Horticultural Spectrophotometer and will hereafter be referred to as the "Hortispect."

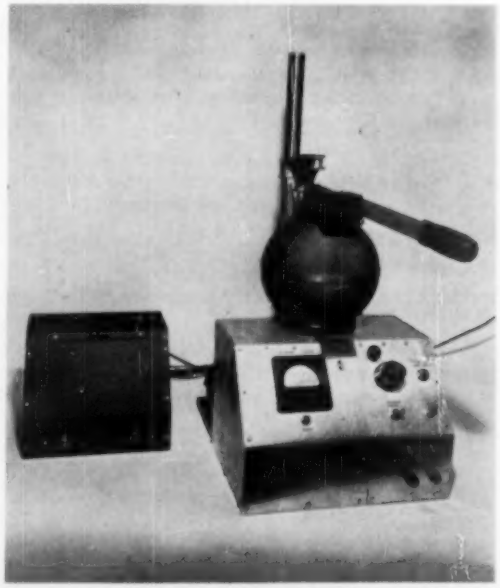

**Figure 1. The Hortispect (Horticultural Spectrophotometer).**

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, May 27, 1958, Chicago, Illinois.

## DESIGN OF INSTRUMENT

An instrument to be used as a maturity index should:

1. Be adaptable to a wide range of types and sizes of fruit.
2. Make rapid measurements.
3. Be simple to operate.
4. Not damage the sample.
5. Be portable.

A scanning monochromator is required to measure the wavelength of peak transmittance. The recently developed wedge interference filters appeared to offer a very simple means of obtaining a scanning monochromator, and tests with such filters showed they were quite adequate. Characteristics of this type of filter are shown in Figure 2 for 3 positions of the filter. The desired radiation passed by the filter is the 2nd order transmission and it can be seen that this filter provides a pass band

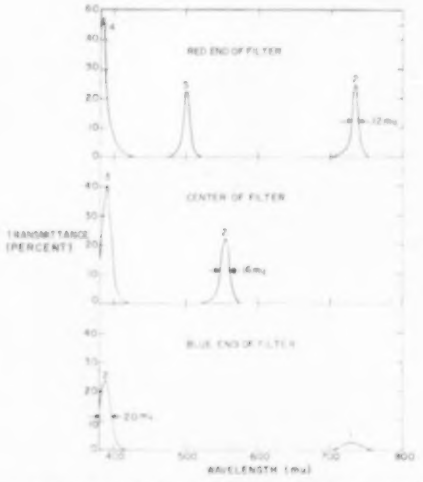


**Figure 2. Spectral characteristics of the wedge interference filter. The numbers above the transmittance peaks indicate the order of the peak.**

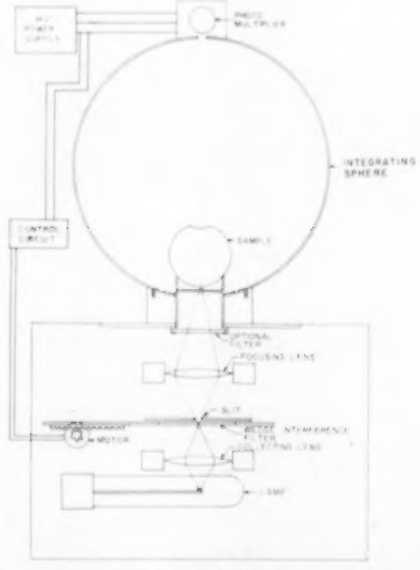


**Figure 3. Diagram of the Hortispect showing the optical arrangement of the instrument, the high voltage power supply, control circuit, and the motor drive.**

which varies in half-width from 20 to 12 mμ as the wavelength is scanned from 400 to 720 mμ. For many applications in spectrophotometry the 1st, 3rd and 4th order transmission would cause serious difficulties, but the spectral characteristics of the elements in the Hortispect can be chosen to eliminate this undesired radiation. Previous work has shown that fruit and vegetable tissues have very low transmittance for wavelengths below 500 mμ. Therefore, the sample eliminates any problem from the 3rd or 4th order transmission bands. The phototube (RCA 6328) has very low sensitivity to wavelengths longer than 700 mμ so the 1st order transmission is not a problem.

The arrangement of components making up the Hortispect is shown in Figure 3. A 6-volt, 100-watt, ribbon filament lamp was chosen as the light source. Imaging this filament on the filter provides a beam of energy sufficiently narrow that a defining slit is not required. However, a slit was placed above the filter to reduce stray light from interreflections. The lenses to focus the lamp filament on the filter and to collect the monochromatic light and focus it on the sample were chosen from standard microscope lenses. Provision was made for inserting a standard 2 x 2 in. filter to correct the system response or reduce stray light if required.

An integrating sphere with the interior surface painted with a high quality white paint was used to collect the energy transmitted by the sample. This provides a summation of all the energy transmitted by the sample and thus gives an evaluation of the average characteristics of the interior of the sample. Use of the integrating sphere to enclose the sample also makes the Hortispect adaptable to a wide range of types and sizes of fruit.

It is important to point out that this measurement is not related to the overall energy level of the transmitted light; consequently, the size of sample does not directly influence the measurement. The only requirement insofar as the energy level is concerned is that there should be enough transmitted light to be measurable.

The amount of energy transmitted through a sample such as a peach or tomato is, of course, very low. Furthermore, the level of this energy varies greatly from one sample to another and for different regions of the spectrum. Thus, a photometer for this purpose must measure signal levels as low as $10^{-8}$ lumens and as high as $10^{-4}$ lumens. This is accomplished by using a multiplier type phototube operated with approximately constant anode current. Under this condition the phototube voltage varies approximately as the logarithm of the reciprocal of the light flux *(5)*, or a measurement of the phototube voltage gives the light level on a scale which is proportional to optical density. This technique, in addition to providing a wide response range, protects the phototube from damage by high light levels, because, as the light increases, the phototube gain decreases.

A synchronous reversible motor is used to drive the filter through the required distance to scan the spectrum. A revolution counter is coupled to the motor drive to indicate the wavelength. This counter reads directly in millimicrons. Power supplied to the motor is controlled by a relay when the scanning direction is from blue to red. The relay in turn is controlled by an electronic differentiating circuit. The function of this circuit is to make the scanning motor operate when the light level on the phototube is increasing, and to stop the motor when the light level is constant or decreasing. A reversing switch is incorporated in the motor circuit so that the filter can be returned to the shortwave position. Snap-action switches are included to limit the travel of the filter to the useful part of the spectrum for this technique. A momentary contact switch is used to start the motor scanning from blue to red. When the level of transmitted light starts to increase, the electronic circuit takes over control of the motor; the motor will then stop at the wavelength of peak transmittance.

An indicating meter is included to measure the phototube voltage. This meter provides a convenient check on the instrument operation since it indicates the level of light being transmitted through the sample. Since this instrument includes a motor driven scanning monochromator the addition of a recorder would provide instrumentation which could record the spectral transmittance curves of intact fruit.

## OPERATION AND PERFORMANCE

In operation, the whole fruit is placed on the sample holder in the integrating sphere and a light-tight seal is made around the base of the fruit with modeling clay. The sphere is lowered to the closed position. With the wavelength scale at the shortwave position the scanning motor is started by pressing the momentary contact switch. This switch is released when the electronic circuit takes control as indicated by an indicator light. The reading on the counter when motor stops is the index of maturation. The motor reversing switch is then thrown and the next sample is prepared for measurement.

The Hortispect was tested for reproducibility with the results shown in Table 1. The first series of readings was made on all 5 tomatoes; then the second series of readings, etc. No attempt was made to reproduce the same position of the tomato in the sphere except to follow the standard procedure of placing the fruit with the axis vertical and the stem end up. These results show that the readings varied approximately ± 1 mμ from the mean. With a range of about 100 mμ between green and ripe fruit this variation represents 1% of the full scale range.

**TABLE 1**
**Reproducibility of the Hortispect**

| Appearance of tomato | Reading in millimicrons | | | | | Average | Greatest difference from average |
|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | | |
| Completely green | 555 | 556 | 554 | 555 | 556 | 555.2 | 1.2 |
| Pink with green shoulders | 616 | 617 | 614 | 614 | 616 | 615.4 | 1.6 |
| Pink with yellow shoulders | 624 | 624 | 623 | 623 | 623 | 623.4 | 0.6 |
| Red with yellow shoulders | 635 | 636 | 637 | 636 | 635 | 635.8 | 1.2 |
| Completely red | 646 | 647 | 647 | 646 | 647 | 646.6 | 0.6 |
| | | | | | | Average difference | 1.04 |

Figure 4 shows how the Hortispect could be used to study the ripening of fruit. Maximum slopes of the ripening curves were found to be proportional to the temperature of the ripening room. Figure 5 illustrates the application of the instrument to determine the stage of maturation of peaches. Data for these curves were secured by taking a random sample of 6 peaches from a tree at intervals of every 2 days; thus, each point is an average of 6 peaches. After about 2 weeks' use in this experiment it was noted that the lamp envelope became darkened. Tests showed that this darkening caused the instrument to give a lower reading relative to the reading obtained when a new lamp was used. This explains why the Hortispect gave essentially constant readings during the August 18–22 period. This difficulty was overcome for the remainder of the test by frequent changing of the bulb, and has since been eliminated by reducing the lamp voltage to 5.8 volts. The area between the broken lines represents the dates at which the peaches would have been picked if they had not been involved in this test. At the end of the test, September 3, the peaches were freely falling off the tree.

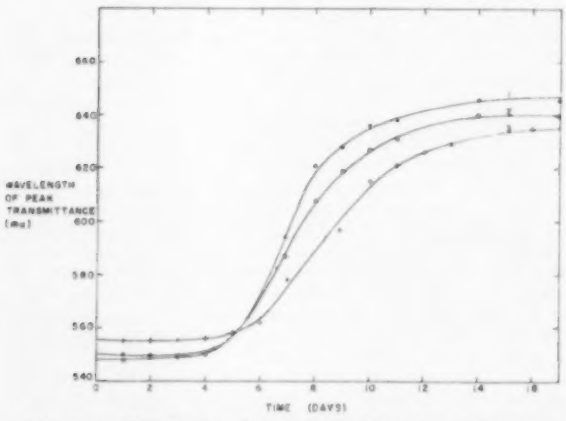


**Figure 4. Wavelength of peak transmittance vs. time curves for three tomatoes during the ripening process. Each tomato was stored at a different temperature; 1 at 70° F., 2 at 65° F., and 3 at 60° F. All the tomatoes showed slight color on the fifth day.**

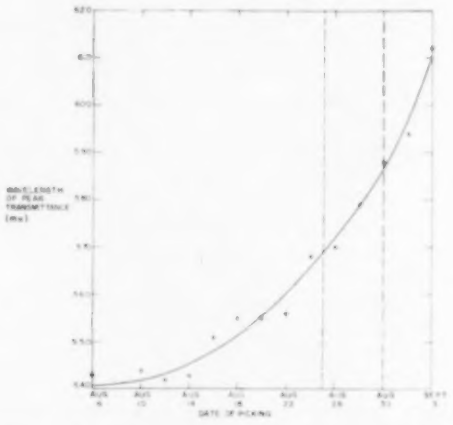

**Figure 5. A plot of the wavelength of peak transmittance vs. time for peaches from an individual tree of the Elberta variety. Each point is an average of 6 peaches.**

A more complete test of the Hortispect applied to determining the stage of maturation of purple plums has been presented by Ernest *et al. (2)*.

## SUMMARY AND CONCLUSIONS

A new criterion, the wavelength of peak transmittance, has been developed for determining the stage of maturation of fruit. A portable instrument employing this principle is described. This instrument is simple and easy to operate; only a few minutes of instruction are required to teach an unskilled worker how to operate the instrument. A determination can be made in about 20 seconds. The measurement is entirely nondestructive and can be made on several types of fruit.

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LITERATURE CITED

1. Birth, G. S., Norris, K. H., and Yeatman, J. N. Nondestructive measurement of internal color of tomatoes by spectral transmission. *Food Technol.*, 11, 552–557 (1957).
2. Ernest, J. V., Birth, G. S., Sidwell, A. P., and Golumbic, C. Evaluation of light transmittance techniques for maturity measurements of prune-type plums. *Food Technol.*, 12, (this issue) (1958).
3. Norris, K. H. Measurement of quality in foods and agricultural commodities by physical methods. *Proc. First Symposium on Food Physics*, Southwest Research Institute, San Antonio 6, Texas, March 15–16, 1956, 113–124.
4. Norris, K. H. Instrumentation to measure light transmittance properties of agricultural commodities. Presented at the Annual Winter Meeting of ASAE, Chicago, Illinois, December 15–18, 1957.
5. Sweet, M. H. An improved photomultiplier tube color densitometer. *J. Soc. Motion Picture Television Eng.*, 54, 35–62 (1950).

# Evaluation of Light Transmittance Techniques for Maturity Measurements of Two Varieties of Prune-Type Plums[a,b]

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(Manuscript received May 31, 1958)

There has long been a need for an accurate and rapid method of measuring degree of maturation of prune-type plums. Firmness, soluble solids, and change in flesh and skin color have been tested as indices of stage of maturation, but none are completely reliable and widely used.

Hartman *(9)* found marked increases in size and sugar content and decreases in firmness and acidity as maturation progressed. During the ripening process in storage, the color of the fruit continued to develop. There was a decrease in firmness and acidity, and a very slight decrease in sugar and other soluble solids. He concluded that the pressure test was the best and most reliable method of indicating stage of maturation. Tucker and Verner *(13)* also recommended the use of the pressure test after concluding that changes in acid and sugar content were too variable with flavor and firmness to be reliable indices. Fisher *(5)*, on the other hand, stressed the importance of the sugar content and recommended that soluble solids be used as the index of degree of maturation. He concluded, after a 3-year study, that firmness was an unreliable guide of maturation mainly because it failed to correlate with sugar content, which was his principal index of quality. Gerhardt and Schomer *(8)* and Gerhardt, English, and Smith *(6)* reported that changes in skin and flesh color, in conjunction with soluble solids, and especially solids-acid ratio, were practical methods of determining degree of maturation. After a study of French prunes, Claypool and Kilbuck *(3)* considered color of flesh and skin to be the most reliable single index of degree of maturation, but suggested that this be supplemented by soluble solids and firmness measurements. They measured the color of the flesh by mounting a flesh segment $\frac{1}{16}$-inch thick on white bond paper and matching it with charts in a Maerz and Paul color dictionary. These readings were then converted to the Munsell color system. Wiley and Worthington *(11)* measured flesh color of the Italian prune with the Hunter Color Difference Meter. They found "a" readings on this instrument to be fairly discriminating for fruit harvested at 3-day intervals, although they indicated the pressure test to be the most precise index of degree of maturation. Continuing on the idea of measuring the flesh color of fruit, Norris *(11)* devised an instrument capable of indicating the internal color of intact fruit through the use of transmittance measurements. Birth, Norris, and Yeatman *(2)* were able to follow the ripening of tomatoes by recording the ratio of a pair of wavelengths of spectral transmittance. This same paper stated that a portable instrument was being designed to measure the wavelength of peak light transmittance of intact fruit. Comparison of this technique and instrument, tentatively called the "Hortispect" *(1)*, with previously

[a] Also called "purple plum" in the fruit canning industry.

[b] Presented before the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 27, 1958.

developed indices of maturity is the subject of this paper.

## EXPERIMENTAL

This study covered research on 2 varieties of prune-type plums, Italian Prune and Stanley, obtained from an orchard near Gettysburg, Pennsylvania. The Italian Prunes were secured under the local variety name "Fellenberg",[c] and are so designated in the results and discussion section. Fifty plums of each variety were picked at random from the same tree at 1-week intervals and brought to the laboratory to be tested. Ten plums from each variety were numbered and were read every other day on the "Hortispect." Samples were stored at 55° F. and every 3 days, 7 plums from each harvest were analyzed for soluble solids and titratable acidity and tested for shear resistance and flesh color. Methods were:

1. *Hunter "a" readings.* The plum was peeled and a piece was cut on each side parallel to the suture and ⅛-inch away from the pit. This flat surface was exposed to the Gardner Color Difference Meter.[d] A Gardner dark yellow ceramic tile was used as the standard with assigned values of Rd = 27.9, a = −3.1, b = +35.0.

2. *Shear resistance.* One-hundred grams of peeled and pitted fruit were tested for shear resistance on the Maryland Shear Press. A recording mechanism devised by Decker *et al. (4)* was used for graphing the maximum force required to shear the sample. This method is felt to give information similar to that given by hand-pressure testers.

3. *Soluble solids.* Part of the 100-g. sample was pressed through thicknesses of cheesecloth, and the expressed juice was used for a soluble solids reading on a Bausch and Lomb hand refractometer (0–60%).

4. *Acid.* The 100-g. sample was placed in a Waring blender with 500 cc. of distilled water and blended for 5 minutes. This puree was strained through cheesecloth; 25 cc. of the filtrate was diluted to 250 cc. and 10 cc. aliquots were titrated in triplicate with .01 N NaOH, using bromthymol blue as the indicator.

5. *Readings of wavelength of peak transmittance.* The operation of the "Hortispect" was rapid and simple. The intact fruit was placed over a light beam and the integrating sphere was placed over the fruit. Power was switched on and the reading of the wavelength of peak light transmittance was automatically registered on a dial. This operation took about 20 seconds per fruit. Due to the difficulty of making a satisfactory light seal around the suture of the plum, an alternate standard procedure was used in presenting stone fruit to the instrument. This procedure consisted of placing the fruit with the axis horizontal and with the suture side up.

The terminology of fruit maturation and ripening follows Lott's recommendation *(10)*. Statistical methods used were those of Snedecor *(12)*. All correlations are significant at the 0.01 level unless otherwise indicated.

## RESULTS AND DISCUSSION

Weekly harvests were made on the Fellenberg and the Stanley varieties of prune-type plums, beginning at a date 30 and 40 days before maturity of the respective varieties. Wavelength readings of peak light transmittance of the fruit taken on the "Hortispect" were found to increase from ca 540 mμ to ca 640 mμ. This indicates a hue shift from green toward red, but

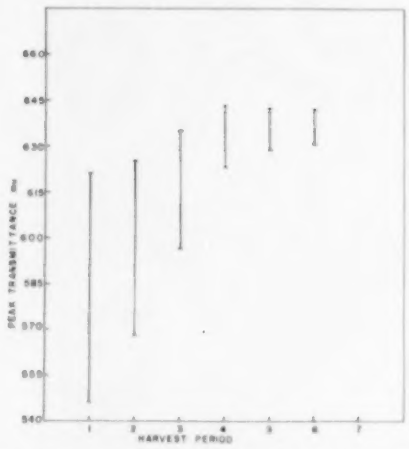


**Figure 1. Change in wavelength of peak transmittance of 10 plums of Fellenberg variety. The lowest point on each bar is the average wavelength of peak transmittance of the fruit samples when freshly harvested. The length of the bar represents changes due to ripening in storage.**

does not indicate a corresponding change in dominant wavelength, as will be pointed out later in the paper. Figure 1 shows the average progression of wavelengths of peak transmittance of 10 fruits due to time of harvest and ripening in storage. The post-harvest ripening period of fruit of the first 4 harvests was 15 days, whereas the ripening period of fruit from the 5th and 6th harvests covered a period of only 8 days because the plums were post-ripe and soon spoiled. The same information for the Stanley variety is presented in Figure 2. In this case, 7 harvests were made and the post-harvest ripening period for each lot was 15 days. The wavelength of peak transmittance for fruit harvested at weekly intervals increased an average of 15 to 20 mμ per week and this rate of increase declined as the fruit approached maturity. The "Hortispect" readings also increased during ripening when the harvested fruit was held in storage at 55° F. This change averaged 3 to 4 mμ per

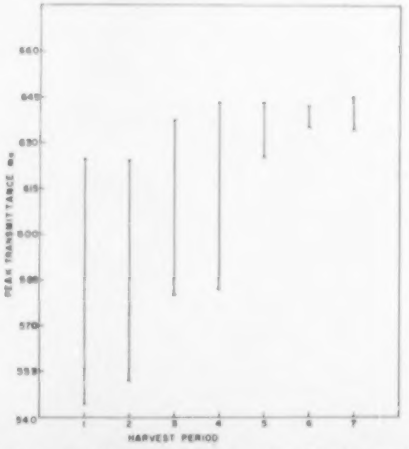


**Figure 2. Duplicate of Figure 1 for Stanley variety.**

[c] "Fallenburg" is an alternative spelling of this old variety name.

[d] A later model of the original Hunter Color and Color Difference Meter now being manufactured by the Henry A. Gardner Laboratories, Inc., Bethesda, Maryland. Mention of this or other commercially manufactured instruments does not constitute endorsement or recommendation by the U. S. Department of Agriculture.

day with this rate of increase declining as the fruit became ripe. A survey of the readings of individual fruit ripening in storage indicated that this average change in peak transmittance was usually appropriate on the individual fruit basis.

Hunter "a" readings made on the Gardner Color and Color Difference Meter showed a greater range than the "Rd" or "b" scales, and so this measurement was studied. These readings also indicate a shift in hue from greenness when negative toward redness when positive. Hunter "a" readings increased from ca −5.0 for Stanley and −2.6 for Fellenberg to ca 4.0 for Stanley and 6.0 for Fellenberg. From the combination of "Rd," "a" and "b" readings, dominant wavelengths were calculated. This progression was from a low of 539 mμ to a high of 587 mμ. A second color parameter, purity, was also calculated from these readings and varied from 44 to 74%. The progression, according to the Munsell system, was approximately 2.5GY 4/5 through intermediate steps to approximately 10YR 2.8/5. Plums ripening in storage developed color similarly to plums which were allowed to mature on the tree. Very early harvested fruit did not reach as high a level of Hunter "a" readings as later harvested fruit. Wavelength of peak transmittance appeared to be related very closely to Hunter "a", particularly in respect to changes during fruit maturation. The correlation between wavelength of peak transmittance and "a" readings was 0.935 for fruit of the Stanley variety and 0.933 for Fellenberg fruit, when only the initial readings of each harvest were considered (Figure 3). When both maturation and ripening effects were considered, the correlation was 0.764 for Stanley and 0.818 for Fellenberg.

Firmness of fruit undergoing ripening, as measured on the Maryland Shear Press, showed a pronounced initial drop, followed by a gradual decline. This was especially true with plums which were put into storage when close to maturity. The shear resistance of fruit maturing on the tree decreased much more gradually. Initial shear resistance was correlated with the wavelength of peak transmittance and was found to be−0.940 and −0.970 for Stanley and Fellenberg varieties, respectively (Figure 4). Correlations of −0.959 and −0.901 for Stanley and Fellenberg were observed when changes in maturation and ripening were considered (Figures 5 and 6).

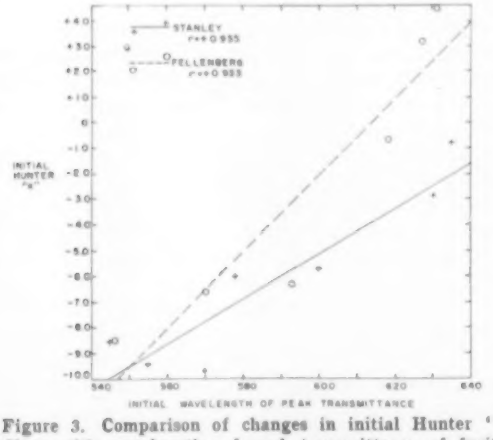


**Figure 3. Comparison of changes in initial Hunter "a" readings with wavelengths of peak transmittance of fruit of successive harvests.**

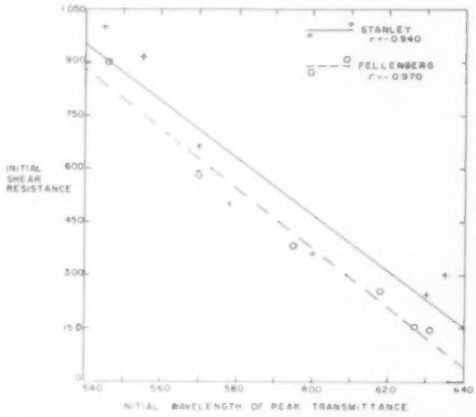


**Figure 4. Comparison of changes in initial shear resistance with wavelengths of peak transmittance of fruit of successive harvests.**

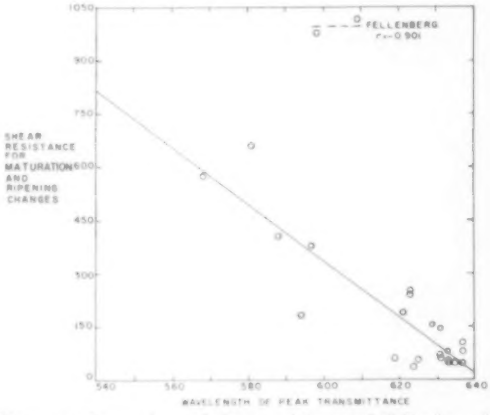


**Figure 5. Comparison of shear resistance of Fellenberg fruit with corresponding wavelengths of peak transmittance, including both maturation and ripening changes.**

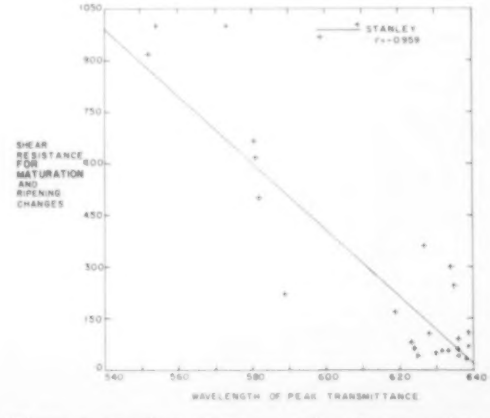


**Figure 6. Duplicate of Figure 5 for Stanley variety.**

As the harvest season progressed the average soluble solids of prune-type plums of Stanley variety increased from 9.3 to 17.0%, while those of the Fellenberg increased from 11.9 to 19.5%. Rate of increase in soluble solids during maturation was greater than that occurring during ripening in storage. Fruit ripening in storage had an irregular and indefinite increase in soluble solids, which ranged from 10.9 to 16.5% for Stanley and from 14.1 to 17.9% for Fellenberg. The correlation between wavelength readings and soluble solids made on freshly harvested fruit was 0.681 for Stanley fruit and 0.977 for Fellenberg. The former correlation was not significant with the small number of samples employed. The correlations were 0.655 and 0.559 for Stanley and Fellenberg, respectively, when ripening changes were included. Fruit held in storage did not reach as high soluble solids content as fruit left on the tree.

A gradual decrease in per cent acid (calculated as malic) was observed in plums which were maturing on the tree, while in storage, the decrease in acid content was irregular. Varietal differences were also found. Average rate of decrease in acid content of Fellenberg variety was similar for maturation on the tree and ripening in storage, being about 0.02% per day. Range of decrease was from 0.92 to 0.39% and from 0.83 to 0.42% for degrees of maturation and ripening, respectively. In the case of Stanley variety, the rate of decrease in acid content was slightly higher during maturation, and much lower during ripening, than the rate of acid decrease for Fellenberg. Correlations of wavelength readings with per cent acid of the latter variety were −0.691 for freshly harvested fruit, which was not significant with the small number of samples employed. The corresponding correlation of Stanley fruit was −0.950%. When ripening changes were included, the correlations were −0.671 for Fellenberg and −0.632 for Stanley fruit.

Among the chemical-type determinations, the soluble solids/acid ratio of the freshly harvested fruit correlated highest with the wavelength of peak transmittance. This correlation was 0.903 for Stanley and 0.889 for Fellenberg fruit (Figure 7). When ripening changes were included in the correlation, a decline to 0.494 and 0.574 was noted for the varieties in respective order. The progression of soluble solids/acid ratio due to harvest was from ca 11 to ca 89 for Stanley and from ca 12 to ca 28 for Fellenberg. During ripening in storage, a progression of 32 to 43 was noted in Stanley fruit and from 20 to 46 in Fellenberg.

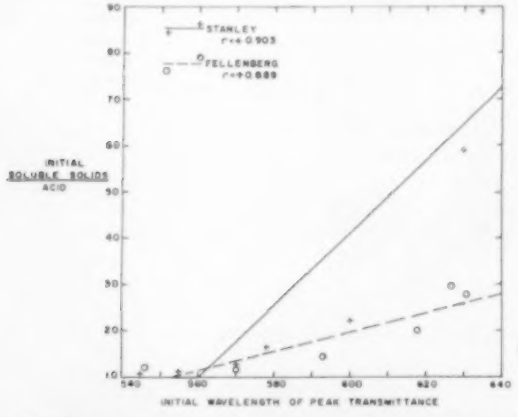


**Figure 7. Comparison of changes in initial soluble solids/acid with wavelengths of peak transmittance of fruit of successive harvests.**

Although this work was done with Eastern (Pennsylvania) fruit, the range of soluble solids and titratable acidity was similar to that reported in Western investigations *(3, 5, 6, 7, 8, 9, 13)*. The only comparable research on color changes is that reported by Wiley and Worthington *(14)*, in which their range of "a" readings was −5.2 to 6.0. This range was similar to that reported in this paper.

The high correlation betwen the wavelength of peak transmittance of the intact fruit and reflectance readings of the cut surfaces of the fruit made on the Hunter "a" scale is considered to be due to the basic similarity of the measurements. The basis of the shift in wavelength of peak transmittance of fruit changing from green toward yellow or red was discussed by Birth and Norris *(1)*. Basis of the shift in "a" can best be understood by references to X, Y, Z measurements from which "a" is derived by the formula $a_{Rd} = 175\ fy\ (1.02\ X - Y)$*. The change in "Rd" was found to be too limited to be useful. Wiley and Worthington reported a similar conclusion *(14)*. Since Rd = 100Y, it follows that this conclusion also applies to "Y" and that the significant changes in the "a" readings are directly related to changes in "X."

Since the "Hortispect" readings of the intact fruit were highly correlated with firmness readings, advocates of this type of measurement might well be interested in the peak transmittance technique. The same statement is also appropriate for the soluble solids/acid measurement, when applied to the problem of estimating degree of maturation.

## SUMMARY

A rapid, nondestructive method has been described using a new electronic instrument, which indicates internal flesh color changes of intact fruit by the wavelength of peak light transmittance passing through the fruit *(1)*. The accuracy and dependability of this instrument has been evaluated by comparing its readings with previously used indices of degree of maturation for prune-type plums. Comparisons of wavelengths of peak light transmittance and indices of degree of maturation were made on plums maturing on the tree as well as on plums ripening in storage.

Loss in firmness occurring during maturation and ripening, as measured by shear resistance, correlated highly with wavelength of peak transmittance. Wavelengths of peak transmittance also correlated highly with Hunter "a" readings, particularly in respect to changes during fruit maturation. A high correlation between wavelength readings and soluble solids/acid of freshly harvested fruit was also observed.

* Where $fy = 0.51\ \frac{(21 + 20Y)}{(1 + 20Y)}$.

**Acknowledgments**

The authors express their appreciation to the Musselman Company of Biglerville, Pennsylvania for supplying the fruit used in this research.

LITERATURE CITED

1. Birth, G. S., and Norris, K. H. An instrument using light transmittance for nondestructive measurement of fruit maturity. *Food Technol.*, **12**, 592–595 (1958).
2. Birth, G. S., Norris, K. H., and Yeatman, J. N. Nondestructive measurement of internal color of tomatoes by spectral transmission. *Food Technol.*, **11**, 552–557 (1957).
3. Claypool, L. L., and Kilbuck, John. The influence of maturity of interior valley French prunes on the yield and quality of the dried product. *Proc. Am. Soc. Hort. Sci.*, **68**, 77–85 (1956).
4. Decker, R. W., Yeatman, J. N., Kramer, A., and Sidwell, A. P. Modifications of the Shear Press for electrical indicating and recording. *Food Technol.*, **11**, 343–347 (1957).
5. Fisher, D. V. A three-year study of maturity indices for harvesting Italian prunes. *Proc. Am. Soc. Hort. Sci.*, **37**, 183–186 (1939).
6. Gerhardt, F., English, H., and Smith, E. The influence of maturity and storage temperature on the ripening behavior and dessert quality of the Italian prune. *Proc. Am. Soc. Hort. Sci.*, **42**, 247–252 (1953).
7. Gerhardt, F., and English, H. Ripening of the Italian prune as related to maturity and storage. *Proc. Am. Soc. Hort. Sci.*, **46**, 205–209 (1945).
8. Gerhardt, Fisk, and Schomer, Harold A. Possible maturity standards for picking early strains of Italian prunes. *Proc. Washington State Hort. Assoc.*, **51**, 185 (1955).
9. Hartman, Henry. Studies relating to the harvesting of Italian prunes for canning and fresh fruit shipment. Oreg. Agr. Exp. Sta. *Circ. 75* (1926).
10. Lott, R. V. The terminology of fruit maturation and ripening. *Proc. Am. Soc. Hort. Sci.*, **46**, 166–172 (1945).
11. Norris, K. H. Instrumentation to measure light transmittance properties of agricultural commodities. Presented at the Annual Winter Meeting of the Amer. Soc. of Agr. Engineers, Chicago, Illinois, Dec. 15–18, 1957.
12. Snedecor, G. W. *Statistical Methods*, 5th ed. 1956. The Iowa State College Press, Ames, Iowa.
13. Tucker, L. R., and Verner, Leif. Prune maturity and storage. Idaho Agr. Exp. *Sta. Bull. 196* (1932).
14. Wiley, R. C., and Worthington, O. J. The use of fresh fruit objective tests to predict the quality of canned Italian prunes. *Food Technol.*, **9**, 381–384 (1955).

# Effect of Moisture and Antioxidant Treatment on Shelled English Walnuts

(Manuscript received May 19, 1958)

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The walnut industry is faced with a continuing increase in production. The problem is complicated by the fact that consumption of inshell or whole walnuts remains practically constant whereas the consumption of shelled walnuts continues to increase. It is apparent that the demand for walnuts shelled and ready for use is growing. This is another example of the trend toward prepared foods, convenient to use in the kitchen. This change in buying habits, from inshell to shelled walnuts, creates a problem the industry must face if this new market is to be properly served. When walnuts are shelled, shelf life is materially shortened *(10)*. Rancidity develops quite rapidly on the grocer's shelf and also in the home.

Considerable progress has been made recently in determining the influence on rancidity of factors such as heat, light, oxygen *(5, 8, 9)* and moisture *(7, 8)*. Also much progress has been made in the use of antioxidants in retarding rancidification of fats and oils *(2, 3, 4, 6)*. In putting this knowledge to use in extending the shelf life of shelled walnuts, it seemed expedient to determine whether or not the measurement of oxygen absorption by shelled walnuts is a suitable method for comparing the activity of various antioxidants and to find the moisture level which had the minimum adverse effect on shelled walnuts during storage. Since oxygen absorption has been used to determine the incipient oxidative rancidity of fats and oils, a method was devised to measure oxygen absorption by walnut kernels in an isolated atmosphere. The development of free fatty acids was also followed during this experiment to see if a relationship existed between them and oxygen absorption and moisture content of shelled walnuts.

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## EXPERIMENTAL PROCEDURE

Freshly shelled walnuts of the Payne variety were divided into three lots. Lot 1 was sprayed with a mixture containing butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) 1:1 dissolved in a vegetable oil. The antioxidant mixture was sprayed at a rate calculated to give a residue of BHA and BHT combined of less than 0.05%. Subsequent analysis by the method of Anglin, Mahon and Chapman *(1)* showed a total of 0.015% BHA and BHT on the walnuts.

Lot 2 was sprayed with a solution containing butylated hydroxyanisole 28%, propyl gallate (PG) 12%, citric acid 6%, propylene glycol 34%, and mono- and di-glycerides 20%. Subsequent analysis showed 0.008% BHA and 0.003% propyl gallate on the walnuts.

Lot 3 was used as the untreated control.

Each of the 3 lots was divided into 5 sub-lots and spread out on large cardboard trays in a controlled humidity room. By use of the hydroscopic equilibria curve for walnuts, described by Rockland *(7)*, sub-lots were brought to the following moistures: 3.0%, 3.5%, 4.0%, 4.5% and 5.0%. As each sub-lot was brought to the proper moisture content, determined on a Cenco moisture balance, 100 g. of shelled walnuts were sealed under full air in each 8-ounce can. All cans were sealed in the controlled humidity room, thus preventing any moisture change.

Cans were then stored in the laboratory at room temperature. At intervals duplicate samples were taken from each moisture level in each lot, and the head space gas analyzed for oxygen using a Beckman Model E2 oxygen analyzer and accompanying apparatus (Figure 1). Determination of the fatty acids was accomplished as follows:

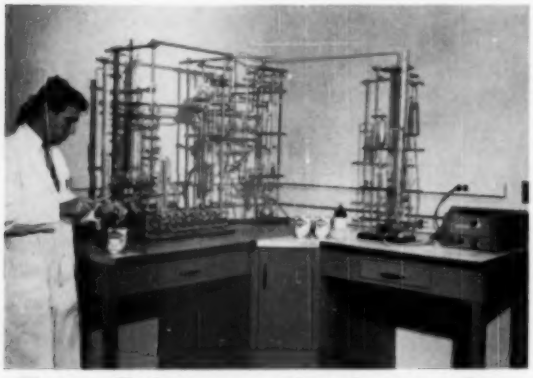

**Figure 1. Headspace gas sampler and oxygen analyzer.**

The sample of walnut kernels is ground in a hand grinder, and the oil expressed by a Carver press. A 5-g. sample of the oil is weighed into a 300 ml. flask. To this sample is added 50 ml. of 95% ethyl alcohol which has been neutralized with 0.1 N KOH (with 1% alcoholic phenolphthalein as indicator). The sample is then brought to a boil and titrated with 0.1 N KOH to a pink end point.

Results are expressed as milligrams of KOH per gram of oil.

The per cent of oxygen absorbed is the difference between the per cent of oxygen in atmospheric air (20.93%) and the per cent of oxygen in the headspace gas after storage.

## RESULTS AND DISCUSSION

Free fatty acids in the control or untreated lot (Table 1) show a general increase as the moisture level of the shelled walnuts increases. Also the relationship of elapse in time to increase in free fatty acid development is well illustrated.

Tables 2 and 3 show that the BHA-BHT and BHA-PG formulations had practically no effect upon the rate of development of free fatty acids but that moisture was again the principal cause of the increased rate. Final analyses show nearly the same free fatty acid content, at a given moisture level, in the untreated and in the antioxidant treated lots.

**TABLE 1**

**Free fatty acid concentration in untreated shelled walnuts[1]**

| Time in weeks | Moisture | | | | |
|---|---|---|---|---|---|
| | 3.0% | 3.5% | 4.0% | 4.5% | 5.0% |
| 0 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 7 | 0.12 | 0.26 | 0.17 | 0.24 | 0.20 |
| 12 | 0.11 | 0.39 | 0.22 | 0.46 | 0.43 |
| 14 | 0.16 | 0.25 | 0.31 | ..... | ..... |
| 16 | 0.17 | 0.22 | 0.35 | 0.37 | 0.37 |
| 34 | ..... | ..... | ..... | 0.66 | 0.73 |
| 37 | 0.29 | 0.39 | 0.56 | ..... | ..... |
| 62 | ..... | ..... | ..... | ..... | 1.12 |
| 65 | ..... | ..... | 0.96 | 1.10 | ..... |
| 66 | 0.33 | 0.62 | ..... | ..... | ..... |

[1] Free fatty acid concentration expressed as milligrams potassium hydroxide per gram of oil.

**TABLE 2**

**Free fatty acid concentration of walnut kernels sprayed with a BHA-BHT solution**

| Time in weeks | Moisture | | | | |
|---|---|---|---|---|---|
| | 3.0% | 3.5% | 4.0% | 4.5% | 5.0% |
| 0 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 8 | 0.11 | 0.17 | 0.22 | ..... | ..... |
| 12 | 0.16 | 0.13 | 0.24 | 0.43 | 0.44 |
| 14 | 0.20 | 0.26 | 0.35 | ..... | ..... |
| 16 | ..... | ..... | ..... | 0.37 | 0.41 |
| 18 | 0.19 | 0.16 | 0.34 | ..... | ..... |
| 34 | ..... | ..... | ..... | 0.68 | 0.76 |
| 38 | ..... | 0.41 | 0.61 | ..... | ..... |
| 61 | ..... | ..... | ..... | 1.10 | 1.10 |
| 64 | 0.34 | ..... | 0.97 | ..... | ..... |
| 67 | ..... | 0.61 | ..... | ..... | ..... |

**TABLE 3**

**Free fatty acid concentration in walnut kernels sprayed with BHA-Propyl gallate solution**

| Time in weeks | Moisture | | | | |
|---|---|---|---|---|---|
| | 3.0% | 3.5% | 4.0% | 4.5% | 5.0% |
| 2 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 8 | 0.11 | 0.17 | 0.17 | ..... | ..... |
| 12 | 0.13 | 0.16 | 0.17 | 0.38 | 0.55 |
| 14 | 0.16 | 0.17 | 0.21 | ..... | ..... |
| 16 | ..... | ..... | ..... | 0.41 | 0.43 |
| 18 | 0.19 | 0.21 | 0.34 | ..... | ..... |
| 34 | ..... | ..... | ..... | 0.68 | 0.75 |
| 38 | 0.22 | 0.39 | 0.63 | ..... | ..... |
| 61 | ..... | ..... | ..... | 1.05 | 1.22 |
| 67 | 0.44 | 0.60 | 0.96 | ..... | ..... |

In Table 4, control, higher moisture resulted in greater absorption of oxygen by the walnut kernels. When treated with the BHA-BHT formulation (Table 5) the oxygen absorbed was reduced to approximately one-third of that absorbed by the control sample.

The BHA-PG formulation (Table 6) reduced the oxygen absorbed to approximately one-half of that absorbed by the control sample.

Antioxidant treatment not only lessens the absorption of oxygen but minimizes the effect of moisture in this respect.

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TABLE 4

Per cent oxygen absorbed by untreated shelled walnuts

| Time in weeks | Moisture | | | | |
|---|---|---|---|---|---|
| | 3.0% | 3.5% | 4.0% | 4.5% | 5.0% |
| 7 | 0.43 | 0.35 | 0.48 | 0.35 | 0.60 |
| 12 | 0.50 | 0.43 | 0.20 | 0.78 | 1.21 |
| 14 | 0.43 | 0.76 | 0.88 | ..... | ..... |
| 16 | 1.15 | 0.85 | 0.90 | 1.25 | 7.68 |
| 34 | ..... | ..... | ..... | 6.73 | 7.89 |
| 37 | 4.34 | 4.85 | 7.74 | ..... | ..... |
| 62 | ..... | ..... | ..... | ..... | 15.78 |
| 65 | ..... | ..... | 14.43 | 13.14 | ..... |
| 66 | 9.53 | 13.52 | ..... | ..... | ..... |

TABLE 5

Per cent oxygen absorbed by BHA-BHT sprayed shelled walnuts

| Time in weeks | Moisture | | | | |
|---|---|---|---|---|---|
| | 3.0% | 3.5% | 4.0% | 4.5% | 5.0% |
| 3 | 0.13 | 0.18 | 0.13 | 0.65 | 0.70 |
| 5 | ..... | ..... | ..... | 0.53 | 0.73 |
| 7 | ..... | ..... | ..... | 0.50 | 0.65 |
| 8 | 0.43 | 0.50 | 0.63 | ..... | ..... |
| 12 | 0.63 | 0.18 | 0.63 | 0.78 | 0.88 |
| 14 | 0.91 | 0.73 | 0.76 | ..... | ..... |
| 16 | ..... | ..... | ..... | 1.26 | 1.70 |
| 18 | 0.97 | 0.55 | 0.78 | ..... | ..... |
| 34 | ..... | ..... | ..... | 2.40 | 3.27 |
| 38 | ..... | 2.09 | 2.11 | ..... | ..... |
| 61 | ..... | ..... | ..... | 4.22 | 4.56 |
| 64 | 3.70 | ..... | 3.60 | ..... | ..... |
| 67 | ..... | 3.71 | ..... | ..... | ..... |

TABLE 6

Per cent oxygen absorbed by BHA-PG sprayed shelled walnuts

| Time in weeks | Moisture | | | | |
|---|---|---|---|---|---|
| | 3.0% | 3.5% | 4.0% | 4.5% | 5.0% |
| 3 | 0.20 | 0.15 | 0.08 | 0.18 | 0.73 |
| 5 | ..... | ..... | ..... | 0.75 | 0.70 |
| 7 | ..... | ..... | ..... | 0.45 | 0.90 |
| 8 | 0.43 | 0.45 | 0.58 | ..... | ..... |
| 12 | 0.25 | 0.08 | 0.25 | 0.78 | 1.36 |
| 14 | 0.91 | 0.11 | 0.86 | ..... | ..... |
| 16 | ..... | ..... | ..... | 1.45 | 1.80 |
| 18 | 0.79 | 0.53 | 1.10 | ..... | ..... |
| 34 | ..... | ..... | ..... | 4.36 | 3.93 |
| 38 | 2.45 | 2.45 | 3.25 | ..... | ..... |
| 61 | ..... | ..... | ..... | 7.45 | 7.95 |
| 67 | 4.45 | 4.37 | 7.23 | ..... | ..... |

From this experiment, it appears that the action of BHA and possibly BHT as antioxidants is mainly one of oxygen blocking rather than selective oxidation. If it were selective oxidation, oxygen would be more rapidly and completely absorbed in the cans containing the antioxidant.

Tables 5 and 6 show that the BHA-BHT formulation is more efficient at blocking oxygen than the BHA-PG formulation at the higher moisture levels. After 34 weeks, however, BHA-BHT is more efficient at all moisture levels.

From the standpoint of free fatty acid formation and oxygen absorption in untreated walnuts, a moisture level of approximately 3.0% is desirable. This agrees with the findings of Rockland *(7)* who found this to be the moisture level at which there is the least change in odor, flavor and color of shelled walnuts. The rate and volume of oxygen absorbed by both antioxidant treated lots are not increased, however, by raising the moisture from 3.0% to 3.5%.

## SUMMARY

Absorption of oxygen from the headspace air in sealed cans containing shelled walnuts was used to compare the efficiency of the two antioxidant formulations used in this experiment. Oxygen absorption was also used to compare shelled walnuts treated with antioxidants against untreated walnuts which gave a measure by which their effectiveness to retard oxidative rancidity could be evaluated.

The effect of various moisture levels on kernel storage life was determined by measuring the free fatty acid concentration.

BHA and BHT, in vegetable oil, when applied to shelled walnuts reduced the oxygen absorbed by approximately two-thirds. The BHA-PG formulation reduced the oxygen absorbed by approximately one-half. Oxygen absorption increases as moisture content increases.

In general the rate of free fatty acid formation also increased as moisture increased, and was not affected by either antioxidant formulation.

### Acknowledgment

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### LITERATURE CITED

1. Anglin, C., Mahon, J. H., Chapman, R. A. Determination of antioxidants in edible fats. *J. Agr. Food Chem.*, **4**, 1018 (1956).
2. Cruess, W. V., and Armstrong, M. Experiments with antioxidants for walnuts. *Fruit Products J.*, **26**, 327 (1947).
3. Dugan, Jr., L. R., Marx, L., Weir, C. E., and Kraybill, H. R. Butylated hydroxytoluene, a new antioxidant for food use. American Meat Institute Foundation *Bull. 18* (1954).
4. Kraybill, H. R., Dugan Jr., L. R., Beadle, B. W., Vibrans, F. C., Swartz, V., and Rezabek, H. Butylated hydroxyanisole as an antioxidant for animal fats. *J. Am. Oil Chemists Soc.*, **26** (9) (1949).
5. Musco, D. D., and Cruess, W. V. Studies on deterioration of walnut meats. *J. Agr. Food Chem.*, **2**, 520 (1954).
6. Olcott, H. S. Antioxidants for fats and oils. 133rd meeting of the American Chemical Society, San Francisco, California (April, 1958).
7. Rockland, L. B. A new treatment of hygroscopic equilibria: Application to walnuts (Juglans regia). *Food Research*, **22**, 604 (1957).
8. Rockland, L. B. Recent progress on the utilization of shelled walnuts. *Diamond Walnut News*, **37** (5) (1955).
9. Tappel, A. L., Knapp, F. W., Urs, K. Oxidative fat rancidity in food products. II. Walnuts and other nut meats. *Food Research*, **22**, 287 (1957).
10. Woodroof, J. G., and Cecil, S. R. Nuts: Better kept—Better candy. *Food Eng.* (11) 129 (1951).

# Studies on a Jacketed Cold-Storage Room[a]

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(Manuscript received May 31, 1958)

ATMOSPHERIC CONDITIONS within the refrigerated-storage room greatly influence the keeping quality of frozen fish. Tests conducted by previous investigators *(1, 2, 6, 8)* have shown that to minimize quality loss during frozen storage, frozen fishery products should be stored (a) at temperatures of 0° F. or lower, (b) at high relative humidity, and (c) at nearly constant temperature. Many frozen-food warehouses constructed in recent years have been designed for operation at temperatures of 0° F. or lower. Conventional methods of providing the refrigeration effect with ceiling evaporators consisting of plain pipe coils, finned pipe coils, or overhead plates have been retained. Evaporator cost, space limitations, and other factors peculiar to this design have limited the amount of evaporator cooling surface area, resulting in 60 to 80% relative humidity in the product storage area.

Although the detrimental effect of low relative humidity in the storage room (resulting in increased dehydration and in loss of quality in some fishery products) has been reduced or completely eliminated through use of moisture-vapor-proof packaging materials and improved packaging techniques, many round (unpackaged) fish or inadequately packaged fishery products are kept in a refrigerated warehouse for considerable periods of time. Seasonal production or inventory needs are the chief reasons for this situation. Round fish may be glazed at regular intervals to prevent excessive loss of moisture and subsequent reduction of quality. Unfortunately, this procedure often results in high labor costs.

Inadequately packaged products therefore present a difficult technical problem. With such products, serious consideration should be given to the use of the jacketed type of cold-storage room. The jacketed room is designed in a manner that permits maintenance of a high relative humidity and nearly uniform storage temperature *(3, 4, 5, 9)*. Cold-storage rooms employing the jacketed principle have been constructed in this country and in Canada. In general, however, industry has been reluctant to accept the jacketed principle. To furnish data on the jacketed type of cold-storage room of the size most suitable for use in a small fishery plant, a jacketed freezer was constructed at the Bureau of Commercial Fisheries Technological Laboratory in East Boston, Massachusetts.

**Objectives.** Objectives of the study were (a) to determine the effect of engineering design on the operating characteristics of a jacketed-type freezer, (b) to obtain data on optimum operating conditions, and (c) to determine the relative keeping quality of fish stored in a jacketed freezer and in conventional freezers.

## DESCRIPTION OF JACKETED FREEZER

The jacketed freezer was so designed that cold air circulates from bottom to top through an enclosed jacket completely surrounding the product storage space (Figure 1). Outside walls of the jacket were constructed of marine plywood and covered on the outside with cork insulation 10 inches thick. Inside walls of the jacket—comprising the walls, ceiling, and floor of the product storage space—also were constructed of marine plywood, with the exception of the floor, which is of fir sheathing. Vertical and longitudinal wooden members arranged within the 3¾-inch wide jacket to provide a system of ducts permit uniform distribution of cold air around the periphery of the 10-foot-square by 8-foot-high storage room (Figure 2). The jacket is essentially a closed-duct system within which are located the evaporator and fans that provide the necessary circulation of cold air. Other features of this cold-storage room are (a) dampers located in the ceiling ducts, to regulate flow of air within individual ducts and (b) doors in the inner walls of the room that may be opened to provide forced circulation of cold air from the jacket directly into the room for rapid initial cooling of the storage space.

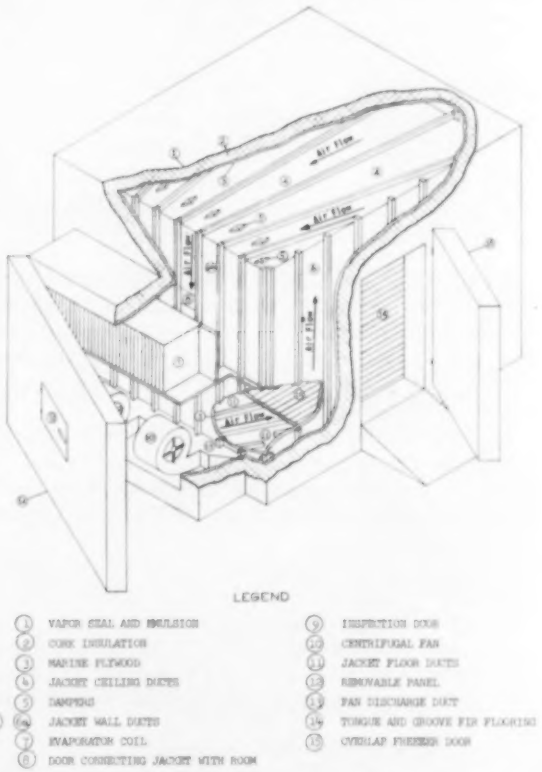



**Figure 1. Cross-sectional view of jacketed freezer used in conducting tests.**

[a] Presented at the Eighteenth Annual Meeting, Institute of Food Technologists, May 28, 1958, Chicago, Illinois.

**Figure 2. Arrangement of floor ducts in jacketed freezer as viewed from fan discharge area.**

Refrigeration is provided by a 7½-horsepower (h.p.), two-stage, water-cooled, Freon 22 condensing unit [capacity 19,400 British thermal units (B.T.U.) per hour at −20° F. refrigerant suction temperature] connected with suitable piping to a finned-pipe coil evaporator located in the jacket. Circulation of air, from bottom to top, in the floor, wall, and ceiling ducts of the jacket and over the evaporator coils is maintained by 2 centrifugal fans, also located in the jacket. Fans are connected by means of a common shaft to a 1½ h.p. motor located outside the freezer. A hot-gas defrosting system—complete with electric time clock, solenoid valves, and heat exchanger, to prevent liquid return to the compressor—permits automatic defrost of the evaporator periodically.

Conventional refrigeration controls consisting of a capillary-type thermostat, low-pressure electrical switch connected to the compressor-motor starter, and electric solenoid valves automatically maintain the freezer at the desired temperature.

## EFFECT OF ENGINEERING DESIGN ON OPERATING CHARACTERISTICS

Studies were carried out to determine the effect of (a) various jacket fan speeds and room-temperature fluctuations on equipment operating requirements and (b) various jacket fan speeds on "room recovery" time due to air infiltration caused by personnel entering and leaving the room.

## METHODS OF MEASUREMENT

In these studies, measurements were made of air flow, temperature, relative humidity, and electrical energy.

**Air-flow measurements.** Air-flow measurements were of 2 kinds: velocity and pressure difference.

*Velocity measurements.* Velocity of the air in the jacket wall ducts shown in Figure 1, except for those ducts located above the door, was measured with a Hastings electric air meter. The instrument consists of a thermopile sensing element that generates a thermal differential voltage proportional to the flow of air over the resistance coils of the element. This differential voltage is transferred by cable to a direct-reading velocity indicator located outside of the storage room.

*Pressure differential measurements.* A Dwyer inclined manometer draft gauge and static pressure tips, designed to eliminate errors due to velocity, were used to measure the static pressure drop across the evaporator and the jacket ducts. The manometer had a range of 0 to 0.10 inch of water and could be read accurately to 0.001 inch of water. It was filled with a red colored oil (specific gravity, 0.826) which has a freezing point below that of the storage room. True pressure differential readings were obtained by multiplying the scale readings by correction factors obtained from the manufacturer's temperature-correction curve. For determining pressure drop across evaporator a static pressure tip was located on each side of the evaporator. One was also located in the fan discharge, and another in the air stream leaving the jacket ducts (entering the evaporator) for determining pressure drop in the jacket ducts.

**Temperature measurements.** Temperature measurements of room air, jacket air, and jacket duct surfaces were made with copper-constantan thermocouples connected by means of a plug-in switchboard to a multi-point recording potentiometer. Six thermocouples were located within the room, and 30 in the air flowing in the jacket ducts. In addition, 40 thermocouples were attached to the outside surfaces of the jacket ducts (inside surfaces of the room). To minimize losses due to conduction, the fixed ends of these thermocouples were held against the wooden surfaces by leather washers, fastened with common wood screws.

**Relative humidity measurements.** Relative humidity measurements were made with Dunmore electric hygrometer equipment, factory calibrated for use at temperatures of 60° to −20° F. The hygrometer equipment consisted of 2 wide-range combination temperature and humidity sensing elements located in the storage room and connected with moisture-resistant cables through a selector switch to an indicator located on a gauge board outside of the storage room. Each sensing element was mounted on a wooden base along with a fractional horsepower fan and a 100-watt light. Circulation of warm air over the element prevented moisture from being deposited on the element and impairing its efficiency. The indicator scale ranged from 0 to 100; both temperatures and humidities were obtained from curves calibrated for each sensing element. Manufacturer's calibration accuracy was stated to be within ± 1.5% of the true relative humidity. Relative humidity in the storage area was calculated also using the formula:

$$H = \frac{P_1 (100)}{P_2}$$

Where H is the relative humidity in per cent, $P_1$ is the vapor pressure of saturated air at dew-point temperature in pounds per square inch (p.s.i.), and $P_2$ is the vapor pressure of saturated air at dry-bulb temperature in p.s.i. Calculations were made with reference to the vapor pressure of ice. Dew-point of the room air was determined on the basis that in an empty refrigerated room withdrawal of moisture from the air will occur until the dew-point of the air reaches the temperature of the coldest evaporator surface within the room *(2)*. The lowest jacket surface duct temperature obtained during each test therefore was used as the dew-point temperature. Dry-bulb temperature was obtained with a thermocouple located in the room.

**Electrical energy measurements.** The electrical energy required to operate the refrigeration compressor motor and the jacket fan motor was measured with a polyphase watthour meter. Current transformers having a ratio of 4 to 1 and 13.33 to 1 were used in measuring fan and compressor electrical energy requirements, respectively. Kilowatt hours (k.w.h.) of electrical energy were obtained by multiplying the meter readings by the appropriate current transformer ratio.

## EQUIPMENT OPERATING TESTS

This experiment was designed to determine the effect of various jacket fan speeds on jacket air flow and the effect of jacket fan speed and room-temperature fluctuations on jacket duct surface and jacket air temperatures, relative humidity of the product storage area, and electrical energy requirements.

## PROCEDURE

Refrigeration equipment was operated in a manner similar to that which would be employed during commercial practice.

The evaporator was automatically defrosted with hot refrigerant gas every 8 hours. Temperature of the room was controlled by a standard thermostat located in the jacket air chamber [b] and set at a fixed temperature lower than that of the room temperature. The refrigeration compressor was automatically "cycled" on and off by means of a low-pressure switch actuated by the refrigerant suction pressure, as described previously. The fan was operated continuously except during the defrost period.

Room temperature was maintained at 0° ± 0.5° F. and at 0° ± 2.5° F. Tests were conducted at each temperature range using jacket fan speeds of 82, 155, 235, 570, and 990 revolutions per minute (r.p.m.). In all, a total of 10 individual tests were carried out. Operating conditions for each test were standardized for a period of not less than 24 hours prior to recording any data. Measurements of the (a) jacket air flow, (b) temperature of the storage room jacket ducts, and air circulating in the jacket, (c) relative humidity of the storage room, and (d) electrical energy required for the operation of the jacket fan and the refrigeration compressor motors were made during each test over a period of 2 to 3 days.

## RESULTS AND DISCUSSION

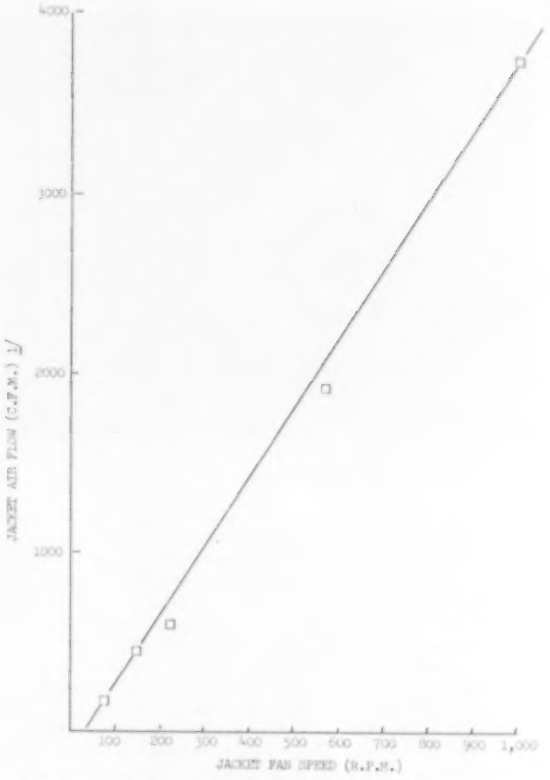
These tests show the effect of various jacket fan speeds on jacket air flow and the effect of jacket fan speed and room-temperature fluctuations on jacket duct surface and jacket air temperatures, relative humidity of the product-storage space, and electrical energy requirements of the equipment.

**Jacket air flow.** Figure 3 shows the jacket air flow in cubic feet per minute (c.f.m.) at various fan speeds. The capacity of the fan varied directly with the speed of the fan in accordance with previously established principles of fan operation (7).

The pressure drop of the air flowing (1) through the jacket ducts, and (2) across the evaporator is shown in Figure 4. As the flow of air through the jacket increases, the slope of the pressure-drop curve also increases, showing an increase of resistance to the flow of air. The increase in the slope of this curve at fan speeds above 570 r.p.m. indicates that for efficient operation, speed of the fan should not exceed 570 r.p.m.

**Temperatures of jacket ducts and jacket air.** The relationship between the temperatures of the jacket-duct surfaces and the room is important in determining suitability of design and establishing operating requirements of the equipment. Jacket-duct surface temperatures higher than or equal to the room temperature indicate that the flow of air is inadequate and that the room is not being properly cooled. Thus, temperatures of the jacket ducts should be lower than that of the room to provide adequate refrigeration. As the temperature differential between ducts and room increases, however, dew-point temperature of the air within the room also decreases. A decrease in relative humidity in the room results. The temperature differential between jacket ducts and room therefore must be large enough to provide adequate refrigeration and small enough to maintain the dew-

[b] This method of control made it possible to use a standard thermostat and take advantage of fluctuations in jacket air temperatures in order to obtain almost constant temperature in the product storage area. Maintenance of a nearly constant room temperature could not have been otherwise accomplished unless a highly sensitive and expensive thermostat was located in the product storage area.




[1] The jacket air flow was calculated from sum of air velocity in ducts on wall 6a (Figure 1).

**Figure 3. Relation of jacket air-flow to jacket fan speed.**

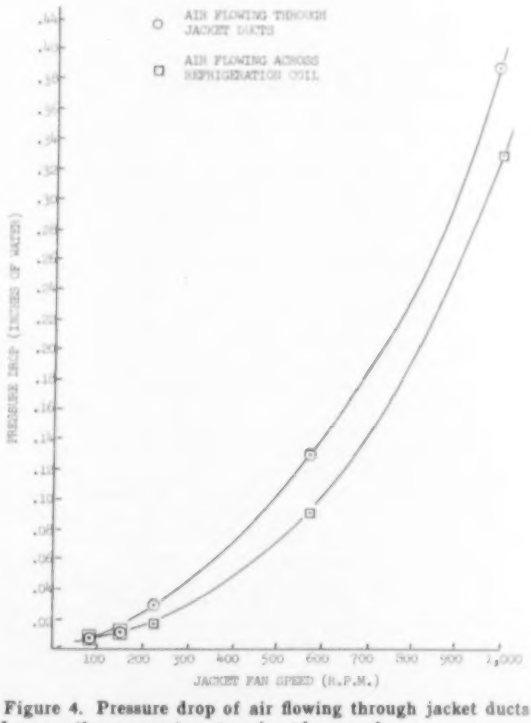



**Figure 4. Pressure drop of air flowing through jacket ducts and across the evaporator at various fan speeds.**

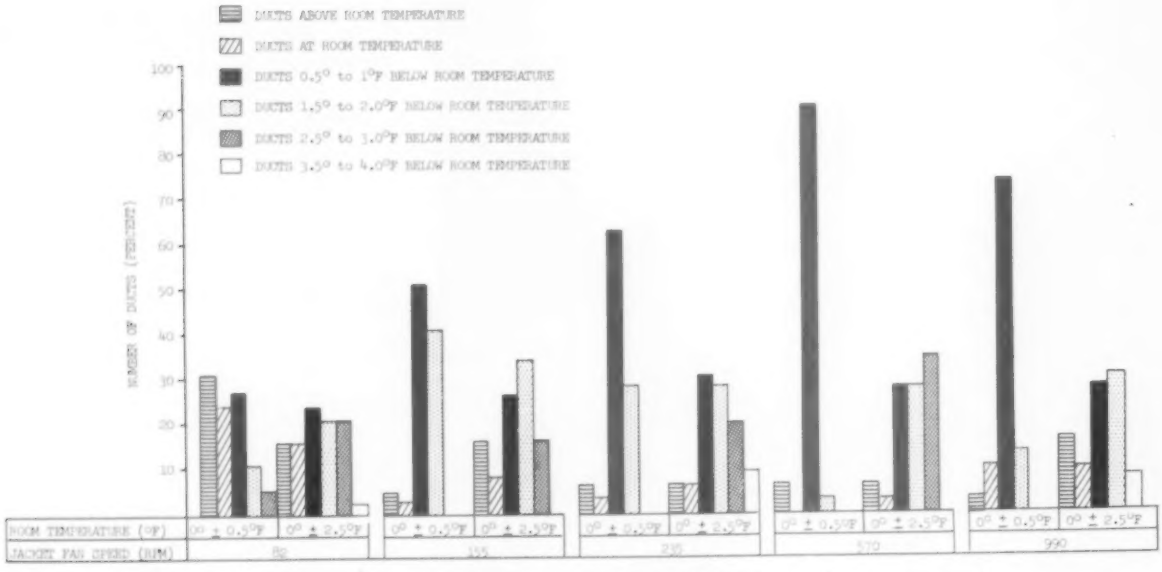



**Figure 5. Effect of jacket fan speed and room temperature fluctuations on jacket duct surface temperatures.**[1]

[1] Temperatures were measured with thermocouples secured to the surfaces, on the room side, of the walls, ceilings, and floor opposite each jacket duct.

point of the air at a temperature that assures a high relative humidity in the product storage space.

The effect of various fluctuations in room temperature and jacket fan speeds on the temperatures of the jacket duct surfaces is shown in Figure 5. Data in this figure show that at a jacket fan speed of 82 r.p.m., circulation of air in the jacket is inadequate as evidenced by the large number of ducts having a temperature above or equal to room temperature. An increase in jacket fan speed from 82 to 570 r.p.m. results in a decrease in the number of ducts having a temperature above or equal to the room temperature. A further increase in fan speed from 570 to 990 r.p.m. results in a very slight increase in the number of ducts at temperature above or equal to the room temperature. This is believed due to high jacket air temperature in some of the ducts resulting from increased frictional resistance due to air flow.

At fan speeds of 155 r.p.m. or higher and room temperatures of $0° \pm 2.5°$ F. (a) more ducts are above or equal to the room temperature, (b) fewer ducts are at the preferred temperatures of only 1° to 2° F. below that of the room, and (c) more ducts are at the undesirable temperatures of 2.5° to 4° F. colder than the room temperature than there are at similar fan speeds and room temperatures of $0° \pm 0.5°$ F.

Therefore, to maintain the temperatures of the ducts at a point that will result in a high dew-point and a minimum number of "hot spots," temperature of the room should be as constant as possible and fan speeds of 155 to 570 r.p.m. should be employed. No advantage is gained from using fan speeds above 570 r.p.m.

Temperatures of the air entering and leaving the jacket ducts at various room temperatures and fan speeds are shown in Figure 6. At room temperatures of $0° \pm 2.5°$ F., the difference in temperature between the air at the jacket duct inlet (fan discharge) and the air from the jacket duct outlet (air entering evaporator) is greater than at temperature fluctu-

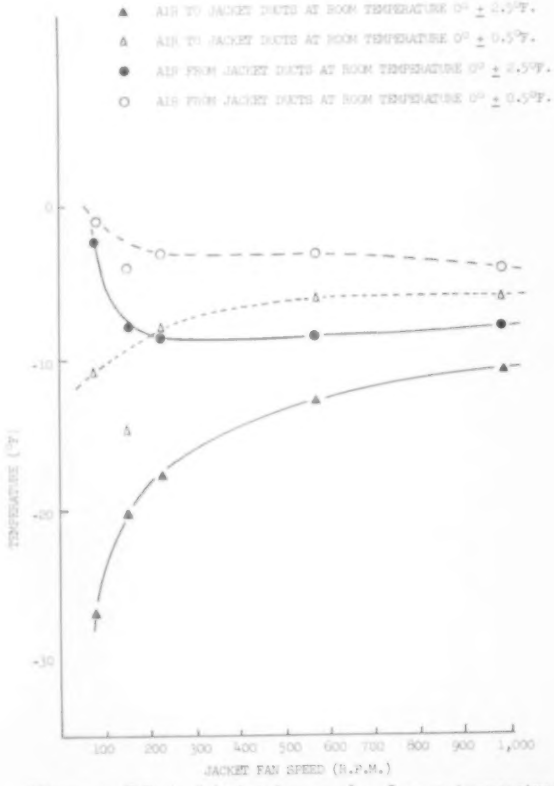

AIR TO JACKET DUCTS AT ROOM TEMPERATURE 0° ± 2.5°F.
AIR TO JACKET DUCTS AT ROOM TEMPERATURE 0° ± 0.5°F.
AIR FROM JACKET DUCTS AT ROOM TEMPERATURE 0° ± 2.5°F.
AIR FROM JACKET DUCTS AT ROOM TEMPERATURE 0° ± 0.5°F.
TEMPERATURE (°F)
JACKET FAN SPEED (R.P.M.)

**Figure 6. Effect of jacket fan speed and room temperature fluctuations on jacket air temperature.**

ations of ± 0.5° F. In addition, the air to the jacket ducts is consistently at a lower temperature at temperature fluctuations of ± 2.5° F. than at fluctuations of only ± 0.5° F. As would be expected, a reduction in fan speed results in an increase in the temperature difference between the air entering and leaving the jacket ducts. This increase in temperature difference, however, is more pronounced at the large temperature fluctuations.

In accordance with the basic principles of thermodynamics, (a) a reduction of air flow under similar refrigerator load conditions or (b) an increase in refrigeration load conditions (for example, by cooling the room 5° F. during each cycle rather than 1° F.) at constant air flow, will result in an increase in the difference between the temperature of the air entering and leaving the jacket. As the jacket air flow increases, however, frictional resistance to air flow also increases (Figure 4). This results in an increase in the amount of heat in the jacket, which must be withdrawn in order to cool the room to the required temperature. An increase in fan speed from 570 to 990 r.p.m. results in a comparatively large increase in jacket air flow (Figure 3) and only a small decrease in the difference between the temperature of the air entering and leaving the jacket ducts, indicating that at fan speeds above 570 r.p.m., considerable refrigeration effect is being used to compensate for heat incurred as a result of frictional resistance. At fan speeds of 155 r.p.m. or lower and room temperatures of 0° ± 2.5° F., the large difference between the temperature of the air entering and leaving the jacket ducts and the low temperature of the air entering the jacket ducts indicate that air circulation is inadequate, resulting in poor heat transfer and inefficient operation of the compressor.

The information indicates that if variable load conditions or fluctuating temperatures prevail, fan speeds of 235 to 570 r.p.m. should be used. If nearly constant load conditions and room temperature are maintained, however, fan speeds as low as 155 r.p.m. may be used satisfactorily.

**Relative humidity.** Figure 7 shows the relative humidity of the product storage space as determined by humidity instrument measurements and by the calculated dew-point temperature of the room air based on the lowest jacket duct surface temperature.

Differences between relative humidities obtained by instrument measurement and by calculation of the dew-point temperature may be due to possible inaccuracy of the instrument at high relative humidities and failure of room environmental conditions to become adjusted, within the period of time allotted for testing, to enable the dew-point of the air to reach the temperature of the coldest jacket duct surface. In view of these limitations and the extreme difficulty in obtaining accurate measurements of relative humidity at temperatures below freezing, this discussion of results is based on a range of relative humidities rather than on exact relative humidities. Since the dewpoint temperature of the empty room would eventually equal that of the coldest jacket duct surface, however, calculated relative humidities are perhaps a

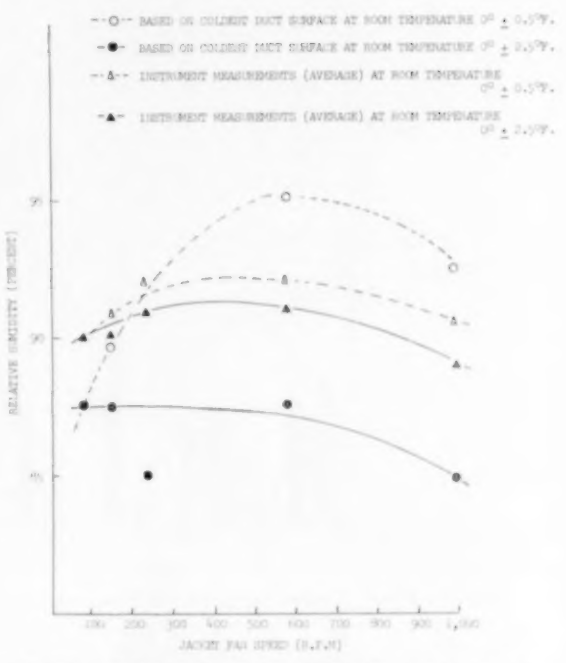

BASED ON COLDEST DUCT SURFACE AT ROOM TEMPERATURE 0° ± 0.5°F.
BASED ON COLDEST DUCT SURFACE AT ROOM TEMPERATURE 0° ± 2.5°F.
INSTRUMENT MEASUREMENTS (AVERAGE) AT ROOM TEMPERATURE 0° ± 0.5°F.
INSTRUMENT MEASUREMENTS (AVERAGE) AT ROOM TEMPERATURE 0° ± 2.5°F.
RELATIVE HUMIDITY (PERCENT)
JACKET FAN SPEED (R.P.M.)

**Figure 7. Effect of jacket fan speed and room temperature fluctuations on relative humidity of the product storage area.**

better criterion of performance than those obtained by instrument measurement.

Relative humidities varied from (a) a low of 87.5 to 90% to a high of 92 to 95% at room temperatures of 0° ± 0.5° and (b) from a low of 87.5 to a high of 92% at room temperatures of 0° ± 2.5° F. Low relative humidities were obtained at a fan speed of 82 r.p.m. and high relative humidities at 235 and 570 r.p.m. for temperature fluctuations of ± 2.5° F. and ± 0.5° F., respectively. An increase in fan speeds above 570 r.p.m. resulted in a decrease in relative humidity. Therefore, to maintain a high relative humidity, room-temperature fluctuations should be kept at a minimum and jacket fan speed should be between 235 and 570 r.p.m.

**Equipment electrical energy requirements.** The electrical energy expressed in k.w.h. per 24 hours required for operation of the jacket air fan and the refrigeration compressor at room temperatures of 0° ± 0.5° F. or 0° ± 2.5° F. and jacket fan speeds of 82 to 990 r.p.m. is shown in Figure 8.

Fluctuations of room temperature do not appreciably affect the electrical energy requirements of the jacket fan. However, as would be expected, an increase in jacket fan speeds results in an increase in fan electrical energy requirements.

At room-temperature fluctuations of ± 0.5° F., a decrease in fan speed results in a decrease in compressor electrical energy requirements, as would be expected. At increased temperature fluctuations of ± 2.5° F., however, the compressor electrical energy requirements decrease with fan speed until a fan speed of 235 r.p.m. is reached; further reduction in

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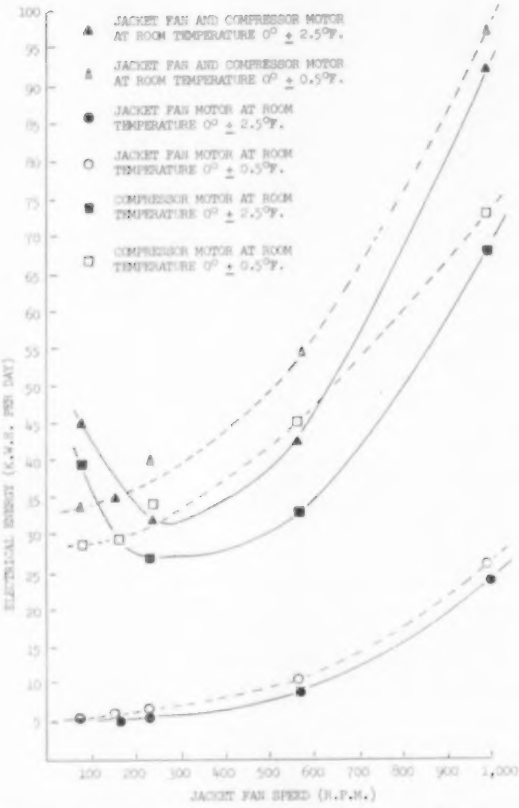
JACKET FAN AND COMPRESSOR MOTOR AT ROOM TEMPERATURE 0° ± 2.5°F.
JACKET FAN AND COMPRESSOR MOTOR AT ROOM TEMPERATURE 0° ± 0.5°F.
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COMPRESSOR MOTOR AT ROOM TEMPERATURE 0° ± 2.5°F.
COMPRESSOR MOTOR AT ROOM TEMPERATURE 0° ± 0.5°F.
ELECTRICAL ENERGY (K.W.H. PER DAY)
JACKET FAN SPEED (R.P.M.)

**Figure 8. Effect of jacket fan speed and room temperature fluctuations on equipment electrical energy requirements.**

fan speed rapidly increases compressor energy requirements.

At fan speeds above 235 r.p.m., high compressor electrical energy requirements at temperature fluctuations of ± 0.5° F. were attributed to the frequent "cycling" of the compressor necessary to maintain a near constant room temperature. At fan speeds below 235 r.p.m., increase in electrical energy requirements at temperature fluctuations of ± 2.5° F. was believed to be due to inadequate circulation of air and the increased refrigeration effect necessary to cool the room at each cycle. As a result, in order to maintain the room at the desired temperature, the compressor operated inefficiently for long periods of time at a comparatively low suction pressure. At fan speeds of 235 r.p.m. or lower, however, circulation of air was sufficient to cool the room 1° F. without excessive operation of the refrigeration compressor.

This information indicates that if room temperature or refrigeration load requirements change appreciably, fan speeds of 235 to 570 r.p.m. should be used to obtain efficient operation of the equipment. If the room temperature is maintained at a nearly constant level, however, and if load requirements are not excessive, costs of operating the equipment may be reduced slightly by using fan speeds of 155 r.p.m. Equipment energy requirements at fan speeds of 155 to 235 r.p.m. are estimated to be 20 to 22% higher than those of a conventional-type still-air room.

## AIR INFILTRATION TESTS

The experiment on air infiltration was designed to determine the relationship between jacket fan speed and time required for the product storage space to return to normal operating temperature (−2° F.) after being subjected to air infiltration caused by passage of personnel in and out of the room. It was found in most instances that personnel enter and leave the freezer on an hourly basis during the working day. Preliminary tests at this laboratory indicate that the refrigerator door may be open as long as 40 seconds each hour as the result of this traffic.

## PROCEDURE

During this experiment the refrigeration equipment was operated as described previously in the equipment-operating tests except that the evaporator was not defrosted and temperature was controlled by a thermostat located in the room, rather than in the jacket. Equipment operation was standardized for 24 hours prior to actual conduct of each test. Tests were conducted at jacket fan speeds of 82, 155, 235, 570, and 990 r.p.m. At each fan speed, the refrigerator door was opened for 40 seconds at hourly intervals. Storage-room temperatures were recorded at 6 different locations in the room by a recording potentiometer.

## RESULTS OF AIR INFILTRATION TESTS

The effect of various jacket fan speeds on the time required for the room to return to its normal operating temperature of −2° F., after being subjected to air infiltration (simulating personnel usage), is shown in Figure 9. Freezer recovery time varied with jacket fan speed. An increase in fan speed from 82 to 570 r.p.m. decreased freezer recovery time from 59 to 18 minutes, respectively. At fan speeds above 570 r.p.m., however, freezer recovery time decreased to 17 minutes and then increased to 19 minutes at 990 r.p.m. These data indicate that no appreciable decrease in freezer recovery time would be obtained by operating the fan at speeds above 570 r.p.m., but that, for rapid recovery, the fan speed should not be less than 235 r.p.m.

## RELATIVE KEEEPING QUALITY OF FISH STORED IN JACKETED FREEZER AND IN CONVENTIONAL FREEZER

Tests are being conducted to determine the keeping quality of fishery products stored in the jacketed freezer, described previously, and in conventional-type cold-storage rooms using overhead plate-type evaporators (laboratory cold-storage room) or finned-pipe-coil evaporators (commercial cold-storage room).

The jacketed freezer is operated at a temperature of −5° F. ± 0.5° F., and the fan speed is maintained at 360 r.p.m. Temperatures of the laboratory and commercial cold-storage room range from 0° to −5° F. Relative humidities were measured with a Dunmore electric hygrometer instrument and were found to be (a) 90 to 95% in the jacketed freezer, (b)

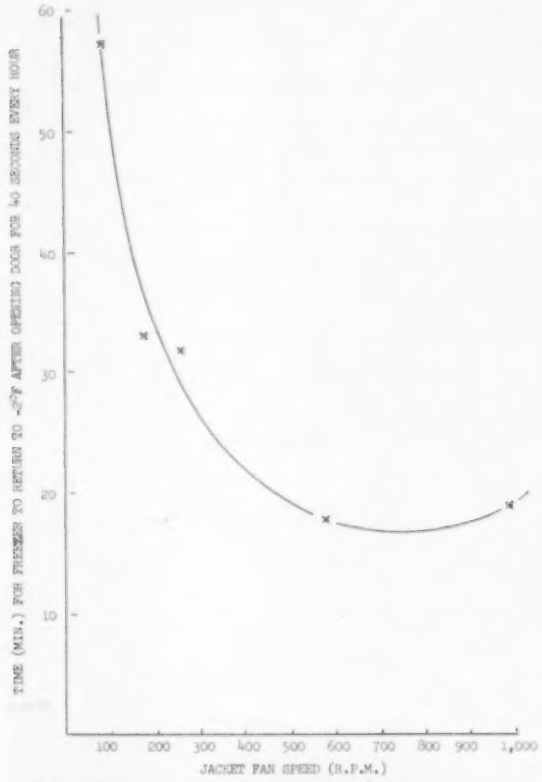

TIME (MIN.) FOR FREEZER TO RETURN TO -2°F AFTER OPENING DOOR FOR 40 SECONDS EVERY HOUR
60
50
40
30
20
10
100 200 300 400 500 600 700 800 900 1,000
JACKET FAN SPEED (R.P.M.)

**Figure 9. Effect of jacket fan speed on time for freezer to return to its operating temperature of −2° F. after being subjected to air infiltration caused by personnel usage.**

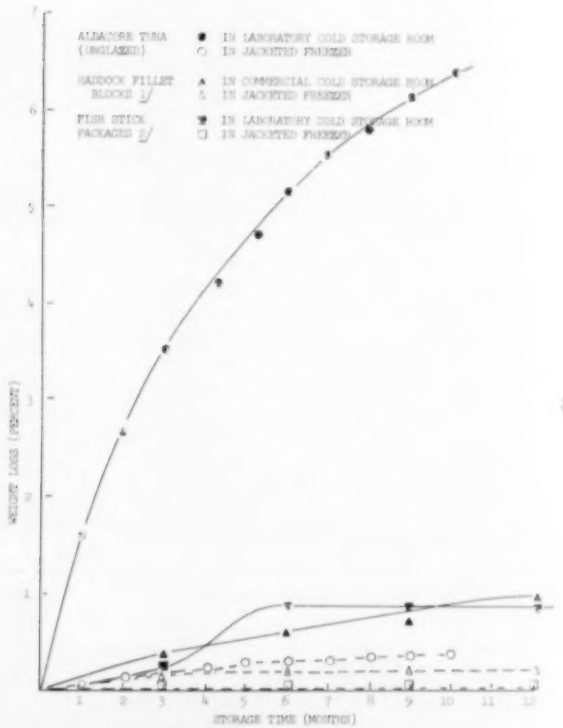
80 to 85% in the commercial cold-storage room, and (c) 70 to 80% in the laboratory cold-storage room. Some preliminary results of storage tests on frozen shrimp, haddock fillet blocks, haddock fish sticks, and round albacore tuna follow.

**Shrimp.** Commercial samples of peeled, deveined, individually frozen and glazed, pink shrimp, packed in waxed chipboard cartons and overwrapped with waxed bleached sulfite paper, are being stored in the jacketed freezer and in the laboratory cold-storage room. Appearance of these shrimp after 9 months' frozen storage is shown in Figure 10. Shrimp stored in the jacketed freezer have retained their glaze and normal "pink" color. Shrimp stored in the laboratory cold-storage room are faded and badly discolored, however, showing evidence of considerable dehydration. Appearance of shrimp stored in the conventional cold-storage room was so poor that they were considered unacceptable.

**Figure 10. Appearance of frozen shrimp stored for 9 months at 0° to −5° F. in the jacketed freezer and conventional type freezer.**

**Note, shrimp stored in conventional freezer are badly dehydrated and have lost their glaze, while those in the jacketed freezer still retain some glaze.**

**Haddock fillet blocks.** Commercial samples of haddock fillet blocks (weighing 13.5 pounds each) packed in waxed chipboard cartons without overwraps and stored in the jacketed freezer and in the commercial cold-storage room are being examined at periodic intervals during frozen storage for changes in weight and quality. Results of the examination for weight loss show that after a year of frozen storage, samples stored in the conventional cold storage room lost about 7 times more weight than did samples stored in the jacketed freezer (Figure 11). Results of organoleptic examinations by a taste-panel of 10 judges for flavor, odor, appearance, and texture show both samples to be of very good quality. These tests are continuing.




[1] Packed in waxed chipboard cartons, no overwrap.
[2] Cellophane overwrap.

**Figure 11. Comparison of weight loss of various fishery products stored in a jacketed type and in a conventional type cold-storage room.**

**Haddock fish sticks.** Ten-ounce packages of haddock fish sticks overwrapped with MSAT cellophane have been stored for 12 months in the laboratory cold-storage room and in the jacketed freezer. Figure 11 shows that packages stored in the jacketed freezer have not suffered any measurable weight loss during the 12-month period, whereas those stored in the conventional cold-storage room have lost almost 1% in weight. Results of taste-panel evaluations for flavor, odor, appearance, and texture show a consistent but not significant preference for the fish sticks stored in the jacketed freezer.

**Albacore tuna.** Samples of frozen round albacore tuna (average weight about 54 pounds) have been stored unglazed in the jacketed freezer and in the laboratory cold-storage room for 10½ months. Figure 11 shows that the weight lost after 10½ months of frozen storage by the tuna stored in the conventional cold-storage room is over 20 times greater than the weight lost by the tuna stored in the jacketed freezer. No organoleptic tests have been conducted on these fish.

## SUMMARY

Tests were carried out to determine the effect of engineering design on the operation of a jacketed freezer and on the relative keeping quality of fishery products stored in a jacketed freezer and in conventional freezers.

Engineering tests were concerned with the effect of jacket fan speeds and/or room-temperature fluctuations on jacket air flow, jacket duct and air temperatures, relative humidity of the storage room, and equipment electrical energy requirements. In addition, the effect of various jacket fan speeds on "freezer recovery" time due to air infiltration caused by personnel usage was studied. Results show that relative humidities of 92 to 95% can be obtained at comparatively low rates of jacket air flow, provided storage room temperatures are kept within ± 0.5° F. Larger temperature fluctuations of ± 2.5° F. decrease room relative humidity and necessitate increased rates of jacket air flow in order to accomplish the required refrigeration effect. Equipment electrical energy requirements vary with room temperature and jacket air flow and are estimated to be 20–22% higher than those of a conventional type freezer under optimum operating conditions. Recovery time due to personnel usage increases with reduction in jacket air flow. In the application of a jacketed cold-storage room, particularly a small room of the size of the test room, every effort should be made to keep load conditions as constant as possible in order to maintain a high relative humidity, low rate of jacket air flow, and low cost of operating the equipment.

Frozen-storage tests also were conducted to determine the comparative keeping quality of samples of shrimp, haddock fillet blocks, haddock fish sticks, and albacore tuna stored at a high relative humidity in the jacketed freezer and in conventional type cold-storage rooms using overhead plate or finned-pipe-coil evaporators. Results show that samples stored in a jacketed freezer undergo considerably less dehydration, as evidenced by weight measurements, than do similar samples stored in a conventional-type cold-storage room. The taste-panel could not find significant differences in the quality of the cooked samples, however, as determined by flavor, odor, appearance, and texture that could be attributed to the method of storage employed.

## LITERATURE CITED

1. Beard, Harry R. Storage of frozen seafoods. *Techno-Logic 1, No. 10.* National Fisheries Institute, Washington, D. C. (December, 1949).
2. Butler, Charles, Slavin, Joseph W., Patashnik, Max, and Sanford, F. Bruce. Cold storage design. *The Refrigeration of Fish, Part I—Cold Storage Design and Refrigeration Equipment.* Fishery Leaflet 427, U. S. Fish and Wildlife Service, Washington 25, D. C. (June 1956). pp. 1–74.
3. Huntsman, A. G. The Processing and Handling of Frozen Fish as Exemplified by Ice Fillets. *Bull. Biol. Board Canada,* No. 20, 1931. pp. 44–66.
4. Jacketed freezer cold storage room. *Com. Fisheries Rev.,* **18,** (5) 16–17 (1956).
5. Lentz, C. P. Humidification of cold storages—The jacketed system. *Can. J. Technol.,* 33 (4) 265–278 (1955).
6. Nikkila, Olavi E., and Linko, Reino R. Freezing, packaging and frozen storage of fish. *Food Research,* **21,** 42–46 (1956).
7. Severall, C. N., and Nichols, T. E. Fans, ducts and filters. *Air Conditioning Refrigerating Data Book.* Design Volume, 9th edition, 1955–1956. The American Society of Refrigerating Engineers, New York 1, N. Y. pp. 24–01 to 25–16.
8. Stansby, Maurice E. Changes taking place during cold storage of fish. *The Refrigeration of Fish. Part 3—Factors to be considered in the Freezing and Cold Storage of Fishery Products.* Fishery Leaflet 429 U. S. Fish and Wildlife Service, Washington 25, D. C. (1956). pp. 15–36.
9. Young, O. C. The jacketed principle in Canadian cold storage. *Can. Refrig. J.,* **18,** (11) 21–22 (1952).

# Low-Moisture, Red Sour Pitted Cherries[a]

M. J. Powers, R. Jackson, P. W. Kilpatrick, J. E. Brekke and D. W. Sanshuck

Western Regional Research Laboratory,[b] Albany, California

(Manuscript received May 31, 1958)

A PROCEDURE HAS BEEN DEVELOPED for preparing dried Montmorency cherries that possess good quality and high stability. The process consists essentially of preparing sulfited, individually quick-frozen cherries, drying under vacuum to below 1% moisture, and packaging the product under vacuum.

Joyce *(11)* has published on the preparation of various vacuum-dried fruits. Moisture contents of his products were 4 to 5%, and packaging was in nitrogen gas. Sulfite was omitted except for a low concentration in apples, plums, and peaches. Storage life was reported as around 5 months at 37° C.

Various fruit powders and tomato powder have been reported by the Western Utilization Research and Development Division to be desirable products with high stability *(6, 12, 16, 17, 18, 21)*. Vacuum-dried peaches have been described by Bean, Schultz, and Downes *(3)*, and by Chichester *(4)*. Vacuum-dried meats containing around 10% moisture have been produced by Tappel *et al. (23)*. A low level of volatile flavor intensity has been reported in red sour cherries by Nelson and Curl *(15)*. A recent general review on vacuum drying of foods has been prepared by Harper and Tappel *(7)*.

Use of in-package desiccation has been discussed in detail by Talburt, Hendel, and Legault *(22)*. Reduction of oxygen in packages to enhance storage stability has been reported by various groups, including the Low-Temperature Station at Cambridge *(24)*, the Continental Can Company *(5)*, and the Western Utilization Research and Development Division *(9)*.

Abelow and Flosdorf *(1)* have recently reported upon the effects of using blackened surfaces and of using ribbed aluminum trays to increase drying rates. They divide drying into two stages: (a) high-moisture, moderate-vacuum freeze-drying, and (b) low-moisture, high-vacuum finishing. Jackson, Rickter, and Chichester *(10)* have proposed heating by conduction, infra-red, and dielectric methods. A recent report *(2)* includes results obtained by D. A. Copson on dielectric heating. The "vacuum contact-plate" method has been described by Hay *(8)* and was used by Joyce *(11)*.

## PROCEDURE

**Raw material.** Fresh Montmorency cherries were obtained from Washington (1955 and 1956), Michigan (1957), and New York (1957). The cherries were soaked several hours in cold water, sorted, and mechanically pitted as in commercial operations.

**Antioxidant treatment.** The pre-freezing treatment generally employed was a sulfite dip which consisted of dipping pitted cherries one minute in a 1% solution of sulfur dioxide (made by dissolving 1.7% of potassium metabisulfite in 1% citric acid solution). Another treatment was a 3-minute dip in a solution containing 1% each of ascorbic acid, citric acid, and sodium chloride.

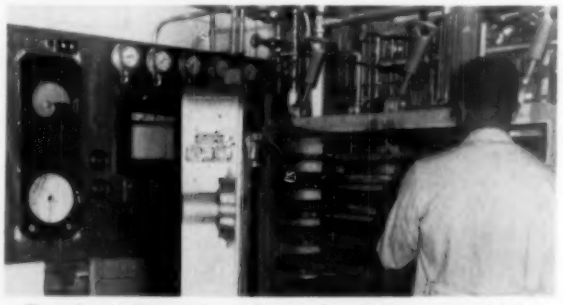
Treated cherries were spread in a single layer on wire-mesh trays and frozen in blast freezers. The frozen cherries were packed into 30-lb. friction-top fruit cans (22 lbs. net wt.) and stored at −10° F.

**Drying.** Individually quick-frozen cherries were rapidly loaded on stainless-steel drying trays (12 × 36 × 1½ inches) at room temperature in a single compact layer with a loading density of around 2 lbs. per sq. ft.

Loaded trays were placed on the shelves of a 60-cu.-ft. vacuum shelf drier. Vacuum was applied by a 3-stage steam ejector, which would reduce pressure to well below 3 mm. in about 5 minutes; a booster-ejector was available which could reduce the pressure to 1.0 mm. in about ½ minute to accommodate rapid evacuation after weighing or sampling. During drying, the pressure could be further decreased to 0.5 mm. over a 3-hour period. Operating pressures within the drier were controlled and recorded by a commercial absolute-pressure controller with a sealed, evacuated, capsule-type diaphragm against which the controller mechanism operated. The pressure controller was frequently checked against two Stokes-McLeod gauges.

Loading and air-evacuating operations were readily performed by 2 operators with no appreciable thawing of the fruit. Drier shelves were then heated (140°, 160°, or 200° F.) by circulation of hot water. Temperatures of the shelves and of the fruit were measured by thermocouples of 30-gauge wire attached to suitable strip-chart recorders.

**Packaging.** The dried cherries were detrayed, mixed, and filled into No. 2 cans in a low-humidity (5% RH at 70° F.) room. Cans were vacuum-sealed immediately in a commercial single-head vacuum closing machine. Packs employing the lowest pressure (6 mm.) were checked by means of a Dubrovin gauge on the closing machine. At lower vacuums a common Bourdon-tube gauge was used. Can seams were carefully checked before and after each batch was processed. In-package desiccants consisted of sealed, stretchable paper bags, each containing 10 g. of calcined lime.



**Experimental samples of cherries being removed from vacuum shelf dryer.**

In preparation for packaging, the cherries were first cooled in the drier (generally to below 90° F. in 30 minutes) to make them firm before the vacuum was broken. The product was removed, mixed, and dispensed at 65 grams per can. Product variables included moisture content (0.5%, 0.8%, and 3.0%). Packaging variables included air pressure in the can (6 mm., 76 mm., and 380 mm.) and the use of in-package desiccants for selected lots (with the net weight of cherries then reduced to 55 g.).

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Mo., June 12, 1956.

[b] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

**Dehydrofrozen cherries.** In an attempt to decrease the time of vacuum drying, some dehydrofrozen cherries were prepared. Fresh pitted cherries were dipped for one minute in 1% $SO_2$ (from sodium metabisulfite) and 1% citric acid. They were dried at around 190° F. dry bulb and 115° F. wet bulb to 50% of original weight in about 90 minutes. The cherries from the drier were of orange-red color and attractive appearance. These partially dried cherries were then individually quick-frozen. Subsequently they were vacuum-dried at 140° F. and 0.5 mm. pressure.

**Moisture and $SO_2$.** Moisture contents down through the 4.0% level were determined by weighing trayloads of dried cherries and noting loss in weight as loss of moisture. Below the 4.0% level the cherries were powdered to pass a 40-mesh screen and the moisture was determined by the Karl Fischer method as modified by McComb and Wright *(14)*. The Karl Fischer method was adopted after comparisons with the vacuum-oven method indicated the titration procedure to be much more accurate. Sulfur dioxide was assayed by the gravimetric method of Monier-Williams *(19)* and by the method of Ponting and Johnson *(20)*, both of which were found to be satisfactory. Moisture equilibria of the dried cherries (as 40-mesh powder) were determined with the apparatus of Legault, Makower, and Talburt *(13)*.

## RESULTS

**Operation variables.** The cherries could be dried at a constant plate temperature of 140° F. without "burning." At this temperature and at 0.5 mm. pressure the time required to reach 2 to 4% moisture (end of evaporative cooling) was around 10 hours; 1.0% moisture was achieved at 12 hours, and 0.5% moisture at around 16 hours. Fruit temperatures and moisture contents during drying are shown in Figure 1. The rate of drying at 0.5 mm. pressure was considerably faster than that at 3.0 mm. (Fig. 1).

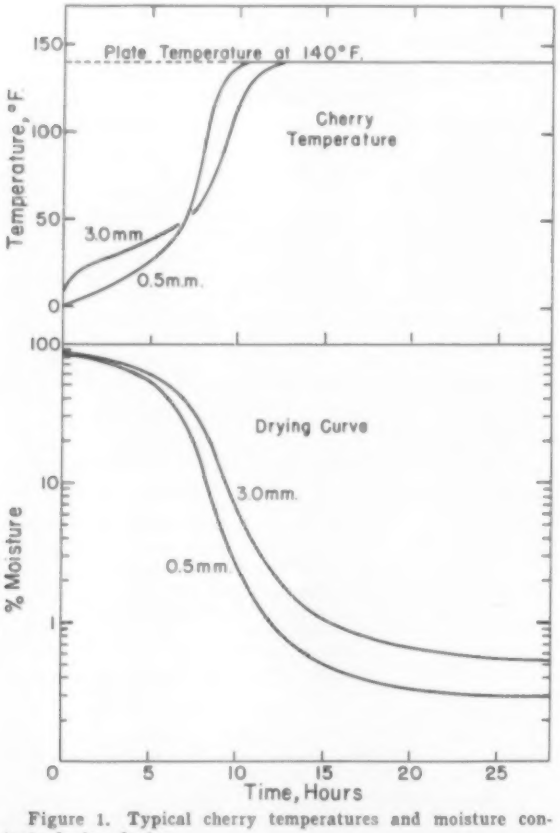



**Figure 1. Typical cherry temperatures and moisture contents during drying.**

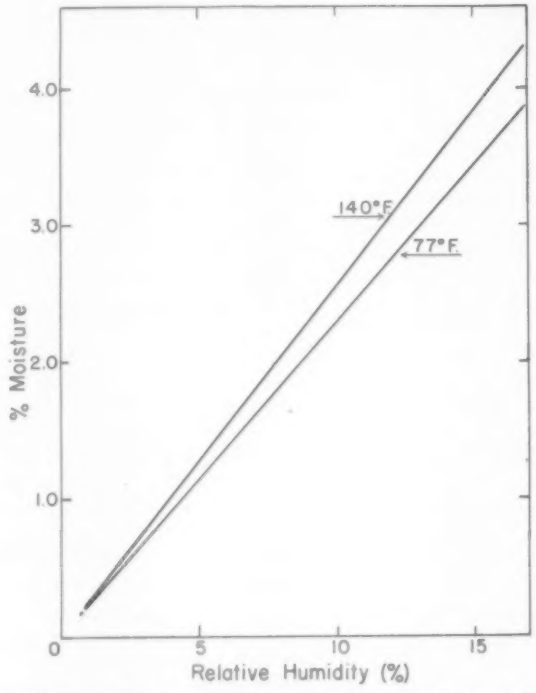



**Figure 2. Moisture content vs. relative humidity for dried cherries (powdered) at equilibrium.**

Drying at a plate temperature of 160° F. and 0.5 mm. pressure to around 0.5% moisture did produce a distinguishable burnt flavor as judged on the dried and the rehydrated products. However, by drying at 200° F. for 5 hours and then cooling the plates to 140° F., 2 to 4% moisture was achieved in 7½ hours' total drying time. No burnt flavor was noted in these samples by a taste panel of 10 people. The rates of drying of different lots of individually quick-frozen cherries were similar, with cherries of 16% soluble solids content taking only slightly longer than those containing 13% soluble solids.

**Moisture content vs. equilibrium relative humidity.** The equilibrium relative humidities of dried cherries (powdered) are shown in Figure 2, to indicate the moisture levels attainable under other drying condition. These can be deduced *(25)* from the formula: %RH = 100 (actual partial pressure of the water vapor in the drier) ÷ (vapor pressure of water at operating temperature).

**Product characteristics.** The dried pie cherries (0.8% moisture) were a deep red color, somewhat shriveled and wrinkled, almost odorless, firm and brittle at room temperature, and were "crunchy" and rich-flavored when eaten. Varying with initial total solids, the cherries were around one-sixth to one-seventh of their original weight. The size of pieces was somewhat larger when the fruit was dried at 0.5 mm. than when dried at 3.0 mm. The dried cherries reconstituted readily to pie filling by heating with about 6 or more parts by weight of 20° Brix sirup. The color on reconstitution was an attractive red. By means of the Hunter Color and Color Difference Meter they were compared with a Gardner color tile (L = 24.4; a = 15.7; b = 4.3). Resulting "a" values of the cherries were around 24. The color of the frozen cherries, prior to drying, was a light orange-red, presumably because of some reversible decolorization by sulfite.

The sulfite content of cherries from Washington prepared with the 1.0% $SO_2$ and citric acid dip was as follows:

| | |
|---|---|
| I.Q.F. cherries, prior to drying | 400 p.p.m. |
| Freshly dried cherries | 2,000 p.p.m. |
| Dried cherries after 6 months at 100° F. | 1,600 p.p.m. |
| Freshly rehydrated, by stewing before baking | 40 p.p.m. |

In order to achieve these sulfite levels, it has been found necessary to raise the concentration of the sulfite solution to above 1.0% for some lots of fruit.

## DISCUSSION

Solid-pack and sirup-pack pie cherries were used in preliminary trials on vacuum drying. When a small lot of solid-pack cherries was thawed, the weight loss as juice was around 30%. Use of individually quick-frozen cherries overcame this defect. There was, however, the usual loss of cherry juice in the initial pitting operation. This juice is normally saved and might be used for other purposes.

The bulk density of the packed dried cherries can be increased by packaging while warm and thermoplastic. Although a 3-fold increase in density can be attained, the product thus packed was difficult to handle. Cherries packed at 130 g. per No. 2 can (twice usual bulk density) were much more readily removed from the package, broken into small clusters, and rehydrated. The 2-fold compression does result in a slight loss in size on rehydration, as compared with the firm, smooth-skinned rehydrated cherries which have not been subjected to compression.

A further review of the methods and conditions of drying used here has revealed some interesting relationships. The data below were compared with drying experiments in which 6 to 18 lbs. of pitted cherries were dried at 140° F. and 0.5 mm. pressure. Under those conditions, the product comes to plate temperature in around 10 hours, at which time the moisture level is in the range of 2 to 4%.

**Effect of pre-drying.** By prior atmospheric drying to 50% of the original weight, the time to the end of evaporative cooling was reduced to about 7 hours.

**Effect of surface contacts.** There is the possibility of drying directly on the heated metal surface, thus avoiding the non-uniform heat transfer from plate to tray caused by uneven and warped metal surfaces. When frozen cherries were dried directly on the drier plates, the time to reach plate temperature was reduced to around 7 hours.

**Effect of radiant heat (blackened surfaces).** When the bottom sides of the plates were repainted from bright aluminum paint to a black color by a Nitrose coating, it was noted on subsequent runs that the drying time was reduced to around 9 hours. When the trays were placed on corks, so that radiant heat only was used, a drying time of around 15 hours was noted, thus demonstrating that radiant heat alone could be effective in drying. It may be recalled that rates of emissivity and absorption are functions of each particular surface and of absolute temperature to the fourth power *(25)*.

**Effect of metal in tray.** Samples were dried on 0.065-inch, type 316 stainless-steel trays and on 0.25-inch 24ST aluminum trays. Ten hours were required to reach plate temperature with the stainless-steel trays and about 9 hours with the aluminum trays. Blackening the bottoms of the trays reduced the drying time by a half hour in the case of the aluminum trays, but less of a reduction in drying time was noted with the steel trays.

**Effect of vacuum.** Although a decrease in absolute pressure, as from 3.0 to 0.5 mm., will save about 2 hours to the 2 to 4% moisture level (Fig. 1) the time saved becomes much greater at lower moisture levels. It would appear, from the standpoint of operating costs to be desirable to use relatively higher pressures in the early steps, followed by lower pressures in the finishing steps.

The ingoing moisture load may influence the vacuum attainable. For example, small loads (12 lbs.) of cherries reached plate temperatures in about 10 hours, while larger loads (125 lbs.) took around 12 hours. This appeared to be correlated with the capacity of the 3-stage steam-ejector employed.

Storage stability of the products will be discussed in a forthcoming paper. Basic engineering studies on variables in freeze drying are also under way and will be reported.

## SUMMARY

Low-moisture cherry pie stock was prepared from frozen pitted Montmorency cherries. Fresh pitted cherries were sulfited, frozen on trays, and stored in cans at −10° F. Subsequently, the frozen fruit was spread uniformly on trays and dried in a vacuum-shelf drier at 0.5 mm. pressure and 140° F. A product moisture content of below 1% was readily attained. Vacuum packaging protected the product from oxygen. The dried fruit was readily converted into pies in which the cherries had bright, red, smooth skins, and a desirable cherry flavor.

### Acknowledgments

The authors are grateful for the assistance of the following staff members of the Western Utilization Research and Development Division: E. A. McComb, G. K. Notter, D. H. Taylor, and L. R. Leinbach. Credit is due to L. H. Walker for suggesting the use of the ascorbic-citric-salt additive to sirups for freezing cherries. Facilities and assistance for the preparation of dehydrofrozen cherries was provided by J. C. Moyer, Division of Food Science and Technology, New York Agricultural Experiment Station, Geneva, New York. Preparation of pies and samples for color measurement was performed by Norma Jean Downes.

### LITERATURE CITED

1. Abelow, I. M., and Flosdorf, E. W. Improved heat-transfer system for "freeze-drying." *Chem. Eng. Progr.*, 53, 597 (1957).
2. Anon. An advance in food preservation. *Canner and Freezer*, 125(11):17 (1957).
3. Bean, R. S., Schultz, T. H., and Downes, N. J. Low-moisture peaches prepared from fresh fruit. *Food Technol.*, 11, 430 (1957).
4. Chichester, C. O. The storage stability of freeze-dried peaches. *Food Technol.*, 10(5), Abstract No. 54 (1956).
5. Continental Can Co., Research Dept. The storage characteristics and packaging requirements of some dehydrated fruits and vegetables. Processed (June 1944).
6. Copley, M. J., Kaufman, V. F., and Rasmussen, C. L. Recent developments in fruit and vegetable powder technology. *Food Technol.*, 10, 589 (1956).
7. Harper, J. C., and Tappel, A. L. Freeze-drying of food products. *Advances in Food Research*, Vol. 7, 171, Academic Press. New York (1957).
8. Hay, J. M. The vacuum contact-plate dehydration of foodstuffs. II. Equipment. *J. Sci. Food Agric.*, 6, 433 (1955).

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9. Hendel, C. E., Burr, H. K., and Boggs, M. M. Factors affecting storage stability of potato granules. U. S. Bur. Agri. and Indus. Chem., processed. AIC-303. (March 1951).
10. Jackson, S., Rickter, S. L., and Chichester, C. O. Freeze-drying of fruit. *Food Technol.*, 11, 468 (1957).
11. Joyce, Alan E. The vacuum contact-plate method of fruit dehydration. *Food Manuf.*, 31, 66 (1956).
12. Kaufman, V. F., Wong, F., Taylor, D. H., and Talburt, W. F. Problems in the production of tomato juice powder by vacuum. *Food Technol.*, 9, 120 (1955).
13. Legault, R. R., Makower, B., and Talburt, W. F. Apparatus for measurement of vapor pressure. *Anal. Chem.*, 20, 428 (1948).
14. McComb, E. A., and Wright, H. M. Application of formamide as extraction solvent with Karl Fischer reagent for the determination of moisture in some food products. *Food Technol.*, 8, 73 (1954).
15. Nelson, E. K., and Curl, A. L. Volatile flavor and fixed acids in Montmorency cherry juice. *J. Am. Chem. Soc.*, 61, 667 (1939).
16. Notter, G. K., Taylor, D. H., and Brekke, J. E. Pineapple juice powder. (Submitted to *Food Technology*).
17. Notter, G. K., Taylor, D. H., and Downes, N. J. Orange juice powder. *Food Technol.*, 12, 363 (1958).
18. Notter, G. K., Taylor, D. H., and Walker, L. H. Stabilized lemonade powder. *Food Technol.*, 9, 503 (1955).
19. *Official Methods of Analysis.* 8th ed. 1955. Association of Official Agricultural Chemists, Washington, D. C.
20. Ponting, J. D., and Johnson, G. Determination of sulfur dioxide in fruits. *Ind. Eng. Chem., Anal. Ed.*, 17, 682 (1945).
21. Strashun, S. I., and Talburt, W. F. Stabilized orange juice powder. *Food Technol.*, 8, 40 (1954).
22. Talburt, W. F., Hendel, C. E., and Legault, R. R. Desiccating in the package. *Food Eng.*, 26(4):79 (1954).
23. Tappel, A. L., Conroy, A., Emerson, M. R., Regier, L. W., and Stewart, G. F. Freeze-dried meat. I. Preparation and properties. *Food Technol.*, 9, 401 (1955).
24. Tomkins, R. G., Mapson, L. W., Allen, R. J. L., Wager, H. G., and Barker, J. The drying of vegetables. III. The storage of dried vegetables. *J. Soc. Chem. Ind.*, 63T, 225 (1944).
25. Walker, W. H., Lewis, W. K., McAdams, W. H., and Gilliland, E. R. *Principles of Chemical Engineering.* 1937. McGraw-Hill Co., New York.

# A Volatile Acidic Flavor Component of Apple Sauce[a,b]

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(Manuscript received May 31, 1958)

The components in apples responsible for their volatile flavor have been reported *(3, 4, 8)* as being alcohols, aldehydes and ketones and esters of formic, acetic, propionic, butyric and caproic acids. During the manufacture of apple sauce some of these volatile compounds are lost in the cooking and filling operation resulting in a lack of flavor in the sauce. Buch *et al. (1)* recommended the addition of apple essence to the sauce, in order to replenish the lost flavor. This practice markedly improves consumer acceptance.

In addition to the flavor lost during processing, apple sauce, upon storage, develops a flavor and an aroma which are disliked by the consumer *(7)*. While the present authors were attempting to define chemically the flavor of apple sauce, they encountered these objectionable flavor-odor qualities, which may be described as "rank" or "tinny." Without question, this rank, tinny flavor and aroma impairs the quality of apple sauce.

In this report, data are presented which establish the identity of the rank volatile flavor as n-caproic acid. It also describes caproic acid formation in stored apple sauce.

## MATERIALS AND METHODS

**Source of apple sauce.** Freshly prepared apple sauce samples were procured from the commercial apple sauce processors in New York State. Samples were stored for one year at room temperature (15–35° C.) prior to analyses. During this storage period, a rank flavor developed. These samples were used to isolate and identify the rank flavor component and also for flavor panel evaluation. Additional sauces were prepared from Baldwin apples for flavor evaluation and storage studies. These apples were processed in the pilot plant, using a continuous line to simulate the average commercial operation in New York State.

**Isolation of the volatile acid for identification.** One hundred grams of apple sauce with 50 ml. boiled distilled water were steam distilled at the rate of 5 ml./min. The steam generator consisted of a three-necked, 500 ml. flask fitted with an internal coil of nicrome wire immersed in boiled distilled water. A

[a] Journal Paper No. 1133, New York State Agricultural Experiment Station, Cornell University, Geneva, New York.

[b] Presented before the Eighteenth Annual Meeting of the Institute of Food Technologists, May 27, 1958.

Friedrich condenser and ice bath served to collect the distillate.

Approximately 200 ml. of distillate was collected. The pH of the distillate was adjusted to 8.30 with N/10 sodium hydroxide, and the resulting solution concentrated to 2–3 ml. by means of a "Roto-Vac" Film Evaporator. The sodium salt of the acid remained; the other volatiles co-distilled with the removal of the water.

**Identification of the rank, volatile component of apple sauce.** The component of the rank, volatile flavor was identified by vapor phase, paper *(5)*, and silicic acid *(6)* chromatography, the neutralization equivalent, and the melting points (uncorrected) of the anilide and p-bromo-phenacyl ester derivatives of the volatile acid from apple sauce.

**Routine analysis of caproic acid in apple sauce.** Since the volatile acidity of the apple sauces was predominately caproic acid, titration of the steam distillate offered an efficient routine method for the analysis of the caproic acid content of apple sauces. Distilling at a rate of 5 ml./min., it was found that the distillation was complete upon collecting 200 ml. distillate. Furthermore, the precision of the steam distillation was found to be adequate for the estimation of the caproic acid content of apple sauces. A series of sauces varying in caproic acid content between 1.5–12 mg./100 g. sauce were analyzed in duplicate. The standard deviation of the difference was calculated to be ±0.20 mg./100 g. The standard deviation of the mean difference was 0.063 mg./100 g. sauce.

**Flavor analysis.** Correlation of the rank odor of apple sauce with caproic acid was tested by submitting sauces naturally containing various concentrations of this acid to a panel of 16 members, and having the panel score the intensity of the rank flavor by using a scoring system of 0–10 where a score of zero indicated the least flavor, and a score of 10, the greatest flavor. The causal relation between caproic acid and the rank odor of the sauce was established by adding caproic acid to a mild flavored sauce and submitting it to the flavor panel for evaluation using the Triangle-Intensity Test of Davis and Hanson *(2)*.

## RESULTS

**Identification of the rank odor of apple sauce.** Steam distillation for one hour at the rate of 5 ml. distillate/min. entirely removed the rank, musty odor and flavor of samples of the stored, canned apple sauce. Neutralization of the steam distillate with N/100 sodium hydroxide destroyed the rank odor. Moreover, the titration curve suggested the presence of a weak acid, since the equivalence point was at pH 8.2. Vapor phase chromatography (carbowax column) suggested the acid to have a rank odor resembling the aroma emitted by the fatty acids between $C_6$ and $C_{10}$. Resolution could not be attained using this method of separation due to large quantities of water; however, the aroma evolved was highly characteristic. Silicic acid chromatography *(6)* showed only one acid to be present in significant concentration. The effluent volume pattern obtained with the silicic acid column agreed well with that of known caproic and acetic acids. Table 1 shows that the proportion of the two acids is fairly constant in several sauces of varying varietal composition. Data illustrated in Table 2 establish the identity of the volatile acid in highest concentration as n-caproic acid.

**Flavor evaluation.** Analyses of a number of apple sauces showed that the concentration of caproic acid ranged from 0–12 mg./100 g. sauce (0–120 p.p.m.). Figure 1 shows that the increasing rank aroma or flavor correlates well with average flavor panel scores. Figure 2 shows that flavor differences in

**TABLE 1**

**Mol per cent of the volatile acids found in various apple sauces**

| Type of apple sauce | Mol per cent | |
|---|---|---|
| | Acid I | Acid II |
| Blend[1] | 96.2 | 3.8 |
| Blend[2] | 94.9 | 5.1 |
| Baldwin | 97.5 | 2.5 |
| McIntosh | 94.5 | 5.5 |

[1] Blend consisted of Rhode Island Greening, Baldwin, Ben Davis, Northern Spy and Wealthy.
[2] Blend consisted of Baldwin, Cortland and Rome Beauty.

**TABLE 2**

**Comparison of the observed constants of the major volatile acid of apple sauce and the reported constants for n-caproic acid**

| Acid | Anilide (m.p.) | p-brom phenacyl ester (m.p.) | Neutralization equivalent | Paper chromatography $R_f$ |
|---|---|---|---|---|
| n-Caproic | 95 | 72 | 116 | 0.64 |
| Volatile acid from apple sauce | 92–93 | 70–72 | 115 | 0.63 |

[1] Using the butanol phase of n-butanol saturated with 1.5 N ammonium hydroxide.

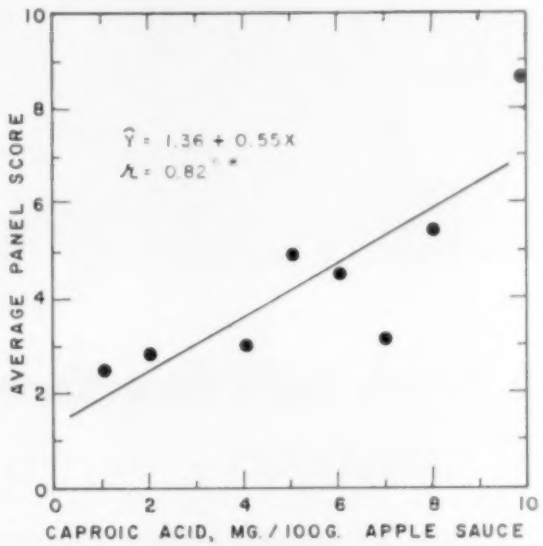


**Figure 1. The relation between panel scores of "rank" flavor and the caproic acid concentration of apple sauces.**

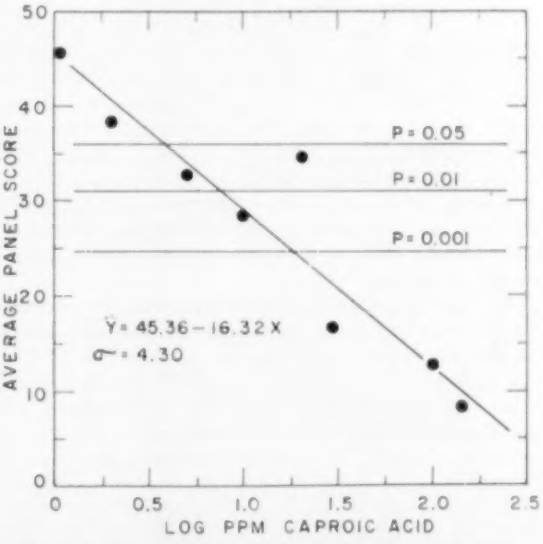


**Figure 2. The effect of caproic acid, added to apple sauce, upon the triangle-intensity score.**

apple sauces may be caused when the concentration of caproic acid differs by only about 5 p.p.m. caproic acid, or 0.5 mg./100 g. sauce. From these data, coupled with the observation that neutralization of the steam distillates of apple sauce destroys the rank flavor, we have concluded that caproic acid is largely responsible for the rank flavor of apple sauces.

**Formation of caproic acid during storage of apple sauce.** Caproic acid is not present in raw apples or freshly processed apple sauce. The formation of caproic acid in stored apple sauce is shown in Figure 3. The apple sauce was made from the variety Baldwin and stored at room temperature (20° C.). Detectable concentrations of caproic acid were formed in the sauce after only about 8 weeks' storage, and continued storage markedly increased the content of caproic acid.

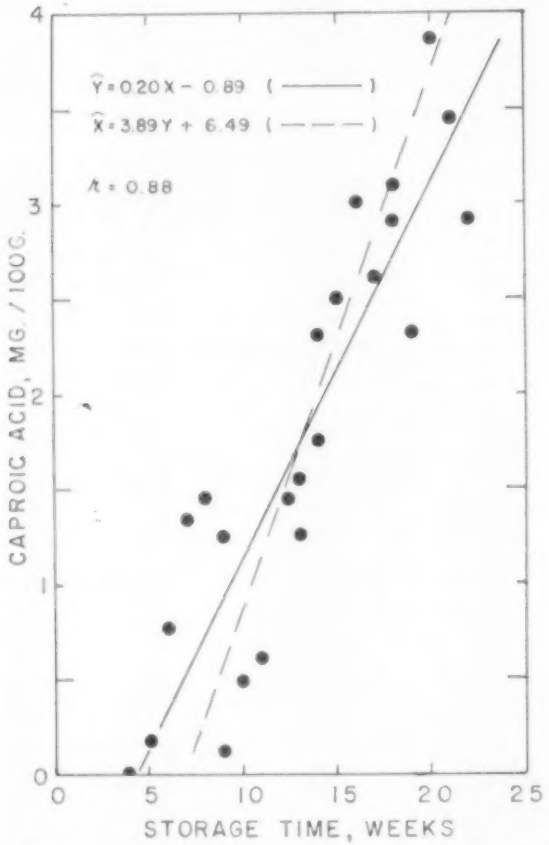


**Figure 3. The formation of caproic acid upon storage of apple sauce.**

## DISCUSSION

The volatile acidity of apple sauce was used as the actual measure of caproic acid. Results obtained by this method showed very good precision, but would tend to be slightly high. This bias is due to the approximate 20:1 molar ratio of caproic acid and acetic acid. If an exact measure of caproic acid was required, then either silicic acid chromatography or approximately 95% of the titratable volatile acidity would give a more accurate value.

n-Caproic acid is classified as one of the "goaty" acids which are responsible for the hydrolytic rancid flavor of butterfat. Its odor and taste are not considered pleasant. Although the flavor panel could detect a concentration of caproic acid of about 0.5 mg./100 g. sauce, concentrations up to 3 mg. were not considered objectionable by the majority of the panel. At a concentration of 8 mg./100 g. apple sauce, however, the caproic acid was objectionable to the majority of the panel. Assuming that the rate of caproic acid formation is linear up to about one year, concentrations objectionable to the majority of our panel would be obtained in about 40 weeks.

The source of caproic acid in apple sauce is not known. White *(8)* found that esters of caproic acid are components of apple essence, but the concentrations of these esters are too low to explain the amount of caproic acid found in apple sauce. On the theory that caproic acid might arise from the reaction between lysine and carbonyl components of the sauce, lysine was refluxed with dextrose until a slight brown color developed. The typical odor of caproic acid could not be detected in this reaction mixture.

## SUMMARY

The major steam distillable acid of apple sauce has been isolated and identified as n-caproic acid. When this acid was added to a relatively bland apple sauce, a taste panel could detect differences of 0.5 mg./100 g. apple sauce. Concentrations of the acid up to 3 mg./100 g. apple sauce were not considered objectionable by the panel; however, concentrations higher than 8 mg./100 g. sauce were evaluated as being very objectionable.

Samples of apple sauce varying in caproic acid concentrations were subjected to a taste panel: Good correlation ($P = 0.01$) between the average score assigned by the panel and the n-caproic acid content of the sauce was obtained.

Storage appears to affect the concentration of this acid markedly. A steady increase in caproic acid was noted with time.

## LITERATURE CITED

1. Buch, M. L., Dryden, E. C., Hills, C. H., and Oyler, J. R. Organoleptic evaluation of apple sauce, fortified with essence and citric acid. *Food Technol.*, **10**, 560–562 (1956).
2. Davis, J. G., and Hansen, H. L. Sensory test methods. I. The triangular intensity (T-I) and related test systems for sensory analysis. *Food Technol.*, **8**, 335–339 (1954).
3. Meigh, D. F. Volatile compounds produced by apples. I. Aldehydes and ketones. *J. Sci. Food Agric.*, **7**, 396–411 (1956).
4. Meigh, D. F. Volatile compounds produced by apples. III. Alcohols and esters. *J. Sci. Food Agric.*, **8**, 313–326 (1957).
5. Reid, R. L., and Lederer, M. Separation and estimation of saturated $C_2$–$C_7$ fatty acids by paper partition chromatography. *Biochem. J.*, **50**, 60–67 (1951).
6. Rice, A. C., and Pederson, C. S. Chromatographic analysis of organic acids in canned tomato juice including the identification of pyrrolidonecarboxylic acid. *Food Research*, **19**, 106–114 (1954).
7. Rothwell, N. D., Bayton, J. A., Mandel, H., and McCormack, T. Consumer preferences regarding apples and winter pears. Agric. Inf. *Bull. No. 19*, U. S. Dept. of Agric. (1950).
8. White, Jr., J. W. Composition of a volatile fraction of apples. *Food Research*, **15**, 68–78 (1950).

# The Influence of Short Term High Temperature Storage With and Without Oxygen Scavenger on the Acceptability of Precooked Irradiated Meat[a,b,c]

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MOST IRRADIATED MEATS have been subjected to radiation as fresh or frozen products *(1, 4, 6, 7, 8, 9)*, but little information is available regarding the effect of irradiating precooked meat items. A number of workers *(3, 5)* have reported that radiation at levels ordinarily used for sterilization does not result in the inactivation of enzymes. This would suggest that enzymatic breakdown continues during storage of irradiated raw meat items. Consequently, cooking prior to radiation would appear to be a logical approach in prevention of enzymatic deterioration during storage. However, Schultz, Cain, Norden and Morgan *(10)* have reported partial or complete cooking prior to radiation may actually intensify undesirable flavors, but have not studied the influence of subsequent storage upon acceptability. The effect of intermittent radiations and concomitant increases in temperature upon acceptability of ground beef has indicated *(4)* that irradiation flavor was dose-dependent but independent of temperature. Again, the effects upon flavor following storage were not studied.

Although informal observations have indicated some improvement in flavor during storage of precooked irradiated meats, controlled studies are not available. Similarly, information is not available in the literature on the role of oxygen in development of off-flavors during radiation, and the diversity of opinion is apparent upon examination of processing procedures in use by various research groups *(2, 6, 8, 9, 10)*.

Consequently, this study was undertaken to determine the effects of short term high temperature storage with and without oxygen scavenger upon the acceptability of precooked irradiated meat products.

## EXPERIMENTAL PROCEDURE

**Studies on beef roasts.** The *Longissimus dorsi* muscle was stripped from paired U. S. Choice wholesale beef ribs. Roasts were cut to fit a No. 2 can and packed in polymylar bags, which were placed in the cans. The unsealed roasts in the cans were placed in an electric oven at 300° F. and roasted to an internal temperature of 160° F. When the internal temperature was reached, roasts were removed from the oven and cooled. The oxygen scavenger (glucose oxidase) was added to one-half of the roasts by placing a packet containing the dry enzyme preparation in the polymylar bags, and 2ml. of 0.2 molar sodium acetate-acetic acid buffer at pH 5.0 was injected into the packet to activate the enzyme. The polymylar bags were heat sealed immediately and the cans were sealed under 28 inches of vacuum. The remaining roasts were treated the same, except that oxygen scavenger and buffer were not added. All cans were stored at 36° F. until removed for radiation or sampling.

In order to test possible differences in response due to variation between different cattle, one unirradiated roast was held at 36° F. and used as a control against an irradiated roast from the same carcass. Roasts were taken to the Fission Products Laboratory at the University of Michigan and radiated with a Cobalt-60 source at a level of 2.79 megarads. Approximately 5 to 6 hours were required to achieve the irradiation level. As soon as the roasts were radiated to the desired dosage, they were returned to our laboratories.

Roasts were then allotted for storage at periods of 0, 1, 5, 10, 20 and 30 days at a temperature of either 100° F. or 125° F. The arrangement was such that all roasts at the same storage period were from the same animal. Furthermore, at the end of each storage period samples were removed by pairs, with one containing oxygen scavenger and the other with no oxygen scavenger. At 0 days, all samples were paired so each judge received an irradiated sample and its corresponding control. Thus, the study was designed to determine whether all cattle responded to irradiation in the same manner.

Prior to submitting the samples to the taste panel, several small cores were removed from the various sections of each can and subjected to bacteriological and toxicity tests. After reasonable freedom from toxins and bacteria was assured, samples were released for panel testing. Clearance for evaluation by the panel usually required 3 days, although on occasions, up to 5 days elapsed prior to release. While clearance was pending, samples were held under refrigeration at 37–40 F. Samples to be submitted to the taste panel were opened and heated for 50 minutes in an electric oven at 300° F. Then the meat was sliced into small samples for the panel. All samples were coded and the panels were arranged so that 18 judgments were made on each item, with each judge receiving a maximum of 6 samples. Although no attempt was made to obtain the same judges at different sittings, a considerable number participated in different panels.

**Studies on pork chops.** Boneless pork loins were cut into ¾-inch thick chops. The chops were then deep fat fried in lard at 280° F. to an internal temperature of 180° F. and placed in polymylar bags. The bags were put in cans, allotted into groups and either treated with oxygen scavenger or used as untreated controls. The bags and cans were sealed as previously described for beef roasts. All cans were radiated at 2.79 megarads, except those used as unirradiated controls. After radiation, the cans containing the chops were allotted for storage at periods of 0, 2, 5, 10, 20, and 30 days. Otherwise the experi-

[a] Journal Article 2219, Michigan Agricultural Experiment Station, East Lansing.

[b] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, QM Research and Engineering Command, U. S. Army, and has been assigned number 854 in the series of papers approved for publication.

[c] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 26, 1958.

mental design was the same as for beef. Thus, comparisons were made between temperatures, between storage periods and between the effects of using or not using oxygen scavenger.

**Studies with roast chicken.** Roasting chickens were boned and approximately equal portions of light and dark meat from the same bird were packed in each polymylar bag and can. The ment was then roasted to an internal temperature of 175° F. in an electric oven held at 300° F. In this study, no oxygen scavenger was used. Storage was at 36° F., 76° F., 100° F. or 150° F. for 0 days, 24, 48, 72 or 96 hours. Otherwise, the roast chicken was handled the same as the beef.

**Studies on veal roasts.** Veal shoulder clods were cut into roasts, placed in polymylar bags and cans, then roasted in a 300° F. electric oven to an internal temperature of 170° F. Temperatures of storage were 76° F., 100° F. and 125° F. with storage periods of 0, 2, 5, 10, 20 and 30 days. The experiment was identical to that used for the beef except that the cans were assigned to the different groups by the use of random numbers. Thus, the variables under study were temperature of storage, length of storage and adding or not adding oxygen scavenger.

## RESULTS

**Beef roasts.** A summary of the differences of radiation and oxygen scavenger responses between cattle is presented in Table 1. It is apparent from the data shown that the control roasts were more acceptable ($P = <.01$) than the radiated roasts regardless of whether or not oxygen scavenger was used. However, differences between individual irradiated samples were not significant.

TABLE 1

**The influence of irradiation and oxygen scavenger upon mean panel scores of roasts from different cattle[1]**

| Cattle No. | Unirradiated control | Irradiated[2] | |
|---|---|---|---|
| | | With oxygen scavenger | Without oxygen scavenger |
| B-5 | 6.60 | 5.30 | 5.20 |
| B-6 | 6.20 | 5.40 | 5.00 |
| B-7 | 6.60 | 5.50 | 5.90 |
| B-8 | 7.00 | 5.89 | 4.50 |
| Means | 6.61** | 5.53 | 5.14 |

[1] Mean panel scores based on 9-point hedonic scale.
[2] Irradiated at 2.79 megarads.
** Difference between means for treatments significant at 1% level.

Examination of the interactions showed that roasts from all cattle responded in the same manner to treatments, as the interactions were not significantly different. Although cattle variation was not significantly different in this study, the similarity in carcass grade, origin and treatment of these animals prior to slaughter does not preclude variation in response under different conditions.

The effects of temperature, length of storage and oxygen scavenger are summarized in Table 2. It is obvious that short

TABLE 2

**Effect of temperature and length of storage on mean panel scores for beef roasts with and without oxygen scavenger[1]**

| | Temperature of storage[2] | | Treatment | |
|---|---|---|---|---|
| | 100° F. | 125° F. | Oxygen scavenger added | No oxygen scavenger added |
| 0 days[3] | 5.25 | 5.20 | 5.53 | 5.14 |
| 1 day | 5.63 | 5.89 | 6.06* | 5.47 |
| 5 days | 5.58 | 6.26** | 5.82 | 6.03 |
| 10 days | 5.19 | 6.67** | 6.36 | 5.50 |
| 20 days | 6.33 | 6.52 | 6.38 | 6.47 |
| 30 days | 6.36 | 5.78 | 6.53** | 5.61 |

[1] Mean panel scores based on 9-point hedonic scale.
[2] Temperature of storage means includes an equal number of samples with and without oxygen scavenger for each value.
[3] Values for 0 days under temperature of storage are means for irradiated roasts from same cattle but without storage.
* Significant at 5% level. ** Significant at 1% level.

periods of storage at 100° F. and 125° F. resulted in improvement of panel scores. The maximum acceptability at 125° F. was reached at 10 days, after which panel scores continued to decline until the end of the study. However, even after 30 days at 125° F., the panel scores were still higher than before storage. At 100° F. storage temperature, the improvement in acceptability was at a slower rate, and the highest score was at 30 days storage. However, the small difference between scores at 20 days (6.33) and at 30 days (6.36) indicated the maximum score most likely occurred between 20 and 30 days. Analysis of variance revealed a significant interaction ($P = <.01$) between temperature and length of storage. Once the maximum score was reached at 125° F. storage, a decline in acceptability commenced, whereas at 100° F. panel scores continued to improve, resulting in narrowing of the difference and an ultimate reversal in ratings.

Observations indicated that there was a gradual breakdown in connective tissue during storage with a resultant loss of product consistency. The roasts would ultimately fall to pieces on removal from the bags. This tendency was observed first at about 5 days for the higher temperature and at 10 days for the lower temperature.

Results of adding oxygen scavenger are not clear-cut, although oxygen scavenger did result in higher scores for all storage periods except for 5 and 20 days, when the reverse was true. Samples containing oxygen scavenger were significantly preferred at 1 day ($P = <.05$) and at 30 days ($P = <.01$). The interaction of storage period and oxygen scavenger was significant ($P = <.05$), indicating the variability of response, which is verified by examination of Table 2.

**Pork chops.** Results of the study on pork chops are summarized in Table 3. The differences between the irradiated and unirradiated pork chops were not statistically significant. Similarly, the differences between temperatures of storage, between storage periods and between the presence or absence of oxygen scavenger were not statistically significant. The interactions length of storage × temperature, length of storage × oxygen scavenger and temperature × oxygen scavenger were not significant. However, the three-way interaction of temperature × length of storage × oxygen scavenger (with or without) was highly significant. Plotting of the values showed that the significant three-way interaction was due to considerable variation in individual samples at 10 days' storage regardless of treatment. Examination of the values at 10 days' storage (Table 3) reveals that at 100° F. the sample with oxygen scavenger was preferred ($P = <.01$) over the one without, but at 125° F. the sample without oxygen scavenger was preferred ($P = <.01$) over the one to which oxygen scavenger was added.

**Roast chicken.** Results of the short term high temperature storage of irradiated chicken are summarized in Table 4. The unirradiated control sample was preferred ($P = <.01$) over the irradiated sample at 0 days, over all samples stored at 76° F. and over the samples stored at 100° F. after 60, 72 and 96 hours. In addition, the unirradiated sample was preferred ($P = <.05$) over all remaining samples except for the one stored at 150° F. for 48 hours, which did not differ significantly. There was no significant difference between the 0 days storage irradiated sample and all other irradiated samples except for those stored at 150° F. for 48 and 96 hours, which were preferred over the 0 day sample at the 5% level. Differences between temperatures of storage were statistically significant ($P = <.01$), with the higher temperatures resulting in a preferred product. Examination of the means for each temperature (Table 4) verify the improvement in panel score associated with the higher temperatures.

**Veal roasts.** Results of the study on veal are summarized in Table 5. At 0 days storage, the unirradiated controls were preferred ($P = <.01$) over the irradiated samples. After 2 days' storage the roast with oxygen scavenger, which was stored at 125° F., was perferred over the roasts with oxygen scavenger stored at 100° F. and 76° F. at the 1% and 5% levels, respectively. Also at 2 days' storage, the samples stored at 125° F. were preferred over the samples stored at 100° F. ($P = <.01$) and 76° F. ($P = <.05$). After 30 days' storage, all samples stored at 125° F. were rated lower ($P = <.01$) than those stored at either 76° F. or 100° F. In the final analysis, there was no

TABLE 3

**The effects of irradiation, temperature of storage and length of storage upon panel scores of pork chops with and without oxygen scavenger[1]**

| Treatment[2] | Level of irradiation | Length of storage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 days | 2 days | 5 days | 10 days | 20 days | 30 days | Means |
| Control–O.S. | 0 | 5.78 | ..... | ..... | ..... | ..... | ..... | ..... |
| Control–No O.S. | 0 | 5.64 | ..... | ..... | ..... | ..... | ..... | ..... |
| Mean–Unirradiated control | | 5.71 | ..... | ..... | ..... | ..... | ..... | ..... |
| Control–O.S. | 2.79 x $10^6$ rads | 6.19 | ..... | ..... | ..... | ..... | ..... | ..... |
| Control–No O.S. | 2.79 x $10^6$ rads | 5.95 | ..... | ..... | ..... | ..... | ..... | ..... |
| Mean–Irradiated control | | 6.07 | ..... | ..... | ..... | ..... | ..... | ..... |
| 100° F.–O.S. | 2.79 x $10^6$ rads | ..... | 5.72 | 6.00 | 5.78** | 6.44 | 6.17 | 6.02 |
| 100° F.–No O.S. | 2.79 x $10^6$ rads | ..... | 6.00 | 6.22 | 3.94 | 5.78 | 6.28 | 5.64 |
| Means–100° F. storage | | ..... | 5.86 | 6.11 | 4.86 | 6.11 | 6.22 | 5.83 |
| 125° F.–O.S. | 2.79 x $10^6$ rads | ..... | 5.94 | 6.61 | 4.72 | 6.78 | 6.11 | 6.03 |
| 125° F.–No O.S. | 2.79 x $10^6$ rads | ..... | 5.55 | 5.78 | 6.22** | 5.83 | 6.05 | 5.89 |
| Means–125° F. storage | | ..... | 5.75 | 6.19 | 5.74 | 6.31 | 6.08 | 6.01 |
| Means for all added O.S. | | 5.98 | 5.83 | 6.31 | 5.25 | 6.61 | 6.14 | 6.03 |
| Means for all no O.S. | | 5.80 | 5.78 | 6.00 | 5.08 | 5.81 | 6.16 | 5.77 |
| Means by storage periods | | 5.89 | 5.81 | 6.15 | 5.17 | 6.20 | 6.15 | 5.90 |

[1] Mean panel scores based upon 9-point hedonic scale.
[2] O.S.= oxygen scavenger (glucose oxidase) added.
No O.S.= no oxygen scavenger added.
** At 10 days' storage, 100° F. O.S. preferred at 1% level over 100° F. no O.S.
At 10 days' storage, 125° F. no O.S. preferred at 1% level over all samples except 100° F. O.S.

TABLE 4

**Summary of mean panel scores of irradiated roast chicken at different temperatures for short periods of storage[1]**

| | 0 days | 24 hrs. | 36 hrs. | 48 hrs. | 60 hrs. | 72 hrs. | 96 hrs. | Means |
|---|---|---|---|---|---|---|---|---|
| Unirradiated | 7.50** | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Irradiated | 5.21 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 76° F. | ..... | 5.39 | 5.22 | 5.55 | 5.11 | 5.05 | 4.72 | 5.17 |
| 100° F. | ..... | 6.00 | 5.83 | 6.05 | 5.00 | 5.25 | 4.50 | 5.44 |
| 150° F. | ..... | 6.05 | 6.11 | 6.66* | 5.89 | 5.92 | 6.17* | 6.13** |
| Means | ..... | 5.81 | 5.72 | 6.09 | 5.33 | 5.41 | 5.13 | ..... |

[1] Mean panel scores based on 9-point hedonic scale.
* Difference significant at 5% level. ** Difference significant at 1% level.

significant difference between temperatures of storage, length of storage periods, and adding or not adding oxygen scavenger. None of the interactions were significant except length of storage × temperature, which was significant at the 1% level.

## DISCUSSION

The data show a distinct difference in the effects of irradiation upon the various meat items. This can best be shown by comparing the results obtained with beef and pork. Although beef roasts developed a marked objectionable flavor on irradiation, the scores for irradiated and unirradiated pork chops did not differ significantly. Since the adverse effects of radiation were evident with veal (the young bovine) as well as with beef (the older bovine) but not with pork, it appears that there is a definite species difference. The roast chicken was also adversely affected by radiation. Thus, indications are that the absence or presence of some constituent in pork tissue either prevents or masks most of the irradiation flavor.

The improvement in flavor observed on storage of beef appears to be a function of both time and temperature of storage, since maximum panel scores occurred sooner at 125° F. than at 100° F. Since the roasts were sealed during the entire storage period, it is obvious that improvement in score was not associated with loss of volatiles. Thus, such flavor improvement would seem to be concerned with changes due to alterations within the product itself. Further support for this theory is obtained by examination of the data for chicken (Table 4), which shows that the panel preferred roasts stored at 150° F. over those stored at lower temperatures. Similarly, the same tendency seemed to occur with veal roasts. As would be expected in view of the fact that radiation did not influence scores of pork chops, length and temperature of storage did not result in any major change in acceptability.

Although adding oxygen scavenger appeared to result in some improvement of score in a few instances, current findings do not justify its usage. It is noteworthy that over-all mean values for beef, pork, and veal all favor the added oxygen scavenger, but there are a number of exceptions to this when analyzed by storage periods. The reason for the discrepancy is not apparent.

Loss of texture observed on storage was apparent with each type of meat, and was most noticeable at the higher temperatures of storage. However, the texture problem also occurred at the lower temperatures but required somewhat longer to develop. It seems likely that loss of texture observed is due to the breakdown of connective tissue during storage. Thus, it is probably associated with a non-enzymatic hydrolysis of connective tissue as a result of the temperature-time-moisture relationship. Such breakdown appears to be one of the major problems in storage of precooked irradiated meats.

Although this study was not specifically designed to test the effects of radiation upon the polymylar package, no adverse effects were noted from the standpoint of either odor or flavor. Thus, results would tend to

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TABLE 5

**The effects of temperature and length of storage upon mean panel scores for irradiated roast veal with and without oxygen scavenger[1]**

| Treatment[2] | Level of irradiation | 0 days[3] | 2 days[4] | 5 days | 10 days | 20 days | 30 days[5] | Means |
|---|---|---|---|---|---|---|---|---|
| Control–O.S. | 0 | 5.31 | | | | | | |
| Control–No O.S. | 0 | 5.39 | | | | | | |
| Mean–Unirradiated control | | 5.35* | | | | | | |
| Control–O.S. | $2.79 \times 10^6$ rads | 4.67 | | | | | | |
| Control–No O.S. | $2.79 \times 10^6$ rads | 4.31 | | | | | | |
| Mean–Irradiated control | $2.79 \times 10^6$ rads | 4.49 | | | | | | |
| 76° F.–O.S. | $2.79 \times 10^6$ rads | | 4.89 | 5.28 | 4.61 | 5.78 | 5.22 | 5.16 |
| 76° F.–No O.S. | $2.79 \times 10^6$ rads | | 5.22 | 5.55 | 4.88 | 4.67 | 4.83 | 5.03 |
| Means–76° F. storage | $2.79 \times 10^6$ rads | | 5.05 | 5.41 | 4.74 | 5.23 | 5.03 | 5.09 |
| 100° F.–O.S. | $2.79 \times 10^6$ rads | | 4.33 | 5.77 | 5.05 | 5.61 | 5.50 | 5.25 |
| 100° F.–No O.S. | $2.79 \times 10^6$ rads | | 5.00 | 5.00 | 5.00 | 5.11 | 5.22 | 5.07 |
| Means–100° F. storage | $2.79 \times 10^6$ rads | | 4.67 | 5.39 | 5.03 | 5.36 | 5.36 | 5.16 |
| 125° F.–O.S. | $2.79 \times 10^6$ rads | | 6.00 | 5.33 | 5.50 | 5.11 | 3.78 | 5.14 |
| 125° F.–No O.S. | $2.79 \times 10^6$ rads | | 5.66 | 5.17 | 5.39 | 4.78 | 3.55 | 4.91 |
| Means–125° F. storage | $2.79 \times 10^6$ rads | | 5.83** | 5.25 | 5.45 | 4.95 | 3.67** | 5.03 |
| Means for all added O.S. | | | 5.07 | 5.46 | 5.05 | 5.50 | 4.83 | 5.18 |
| Means for all no O.S. | | | 5.29 | 5.24 | 5.09 | 4.85 | 4.53 | 5.00 |
| Means by storage periods | | | 5.18 | 5.35 | 5.07 | 5.17 | 4.68 | 5.09 |

[1] Mean panel scores based on 9 point hedonic scale.
[2] O.S.= added oxygen scavenger. No O.S.= no oxygen scavenger added.
[3] At 0 days the unirradiated samples were preferred ($P = .01$) over irradiated samples.
[4] At 2 days 6.00 was preferred over 4.33 at 1% level and over 4.89 at 5% level. None of the other differences were significant.
[5] At 30 days all samples stored at 125° F. were rated significantly lower ($P = .01$) than those stored at 76° F. or 100° F.
* Means significantly different at 5% level. ** Means significantly different at 1% level.

indicate that polymylar was relatively stable when subjected to radiation at either 1.86 or 2.79 megarads.

## SUMMARY

This study was conducted to ascertain the effects of short term high temperature storage upon the acceptability of precooked irradiated beef, chicken, pork and veal. In addition, the effect of adding an oxygen scavenger (glucose oxidase) to all items except chicken was determined.

Results for precooked meat irradiated at $2.79 \times 10^6$ rads indicated that: Pork showed little or no adverse effects from radiation whereas beef, chicken and veal were markedly less acceptable.

Acceptability scores for all cooked irradiated meats studied with the exception of pork appeared to improve with storage at room temperature or above.

Using or not using oxygen scavenger did not significantly influence acceptability, but there was a trend for added oxygen scavenger to result in higher mean scores.

A loss of texture, which appeared to be a function of time and temperature, was apparent on storage.

## Acknowledgments

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## LITERATURE CITED

1. Batzer, O. F., and Doty, D. M. Nature of undesirable odors formed by gamma irradiation of beef. *J. Agr. Food Chem.*, **3**, 64 (1955).
2. Batzer, O. F., Sribney, M., Doty, D. M., and Schweigert, B. S. Production of carbonyl compounds during irradiation of meat and meat fats. *J. Agr. Food Chem.*, **5**, 700 (1957).
3. Becker, R. R., Kung, H. C., Barr, N. F., Pearson, C. S., and King, C. G. Nutritional and biochemical effects of irradiation. *Food Technol.*, 10, 61 (1956).
4. Cain, R. F., Bubl, E. C., and Anderson, A. W. The effect of intermittent radiations and concomitant increase in temperature during radiation on the acceptability of ground beef. *Food Technol.*, 10, 537 (1956).
5. Doty, D. M., and Wachter, J. P. Influence of gamma radiation on proteolytic enzyme activity of beef muscle. *J. Agr. Food Chem.*, **3**, 61 (1955).
6. Erdman, A. M., and Watts, B. M. Radiation preservation of cured meats. *Food Technol.*, **11**, 349 (1957).
7. Groninger, H. S., Tappel, A. L., and Knapp, F. W. Some chemical and organoleptic changes in gamma irradiated meats. *Food Research*, **21**, 555 (1956).
8. Pratt, G. B., and Ecklund, O. F. Organoleptic studies of irradiated foods. *Food Technol.*, 10, 496 (1956).
9. Proctor, B. E., Nickerson, J. T. R., Licciardello, J. J., Goldblith, S. A., and Lockhart, E. E. Extension of food storage life by irradiation. *Food Technol.*, **9**, 523 (1955).
10. Schultz, H. W., Cain, R. F., Nordan, H. C., and Morgan, B. H. Concomitant use of radiation with other processing methods for meat. *Food Technol.*, 10, 233 (1956).

# Consumer Reaction to Rice Enriched With Riboflavin*

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(Manuscript received July 5, 1958)

IT IS MANDATORY that rice sold in South Carolina, Puerto Rico, and the Philippines be fortified with iron, thiamine, and niacin. The term "enriched" has been generally applied in the Philippines to this fortified product; however, by definition, food products labeled enriched must contain specified levels of riboflavin in addition to iron, thiamine, and niacin. The proposed definition and standard of identity for enriched rice, issued by the Federal Food and Drug Administration, provides for a minimum of 2 mg. thiamine, 16 mg. niacin, 13 mg. iron (Fe), and 1.2 mg. riboflavin per pound *(6)*. However, the addition of riboflavin as a requirement has been postponed subject to a future public hearing *(2)*.

The inclusion of riboflavin in the "grain type" premix, of the kind presently used to produce fortified rice for Puerto Rico and the Philippines, leads to a characteristic yellow "leopard spotting" in the cooked rice when it is cooked without stirring *(3)*. This premix is being tested in other countries *(1, 5)*. A powdered premix containing riboflavin, very similar to that used to enrich flour or corn meal, has been successfully used to enrich rice *(3)*. The powdered premix imparts a uniform faint cream tinge to both raw and cooked rice. The question arose as to whether the American homemaker would notice or object to this light cream color. Experienced rice graders of the U. S. Department of Agriculture, working in New Orleans, Louisiana, compared samples of plain rice with rice that had been enriched to 1.2 mg. of riboflavin per pound and concluded that the difference in color was so slight that it would seldom, if ever, result in lowering the grade *(4)*. However, the consumer's reaction to cooked rice which had been uniformly enriched with riboflavin was not known.

Studies were undertaken for the purpose of comparing enriched rice with fortified rice to determine the consumer's reaction: (1) in retail store sales, (2) in panels comparing cooked enriched rice with cooked fortified rice under controlled conditions, and (3) in homes where the two kinds of rice were cooked and served under customary family practices. In this paper, *enriched* rice is rice to which at least 1.2 mg. riboflavin, 2.0 mg. of thiamine, 16 mg. niacin and 13 mg. of iron per pound has been added. *Fortified* rice has had the above ingredients added without the riboflavin.

## EXPERIMENTAL AND RESULTS

The enrichment process was carried out under practical mill conditions by feeding and mixing the specified amount of the powdered enrichment mixture into the stream of rice at the end of the milling and cleaning process. Analysis of the rice for riboflavin content in this laboratory showed that it contained at least the required 1.2 mg. of riboflavin per pound of rice.

**Retail store sales tests.** Long grain rice which had been recently enriched and packaged, and long and short grain rice which had been stored for 3 months in warehouses were used. The longer storage period was used as a means of testing the suggestion that the cream color imparted to the rice by the riboflavin became intensified with time. In both tests the rice was packaged in identical 3-pound transparent cellophane bags bearing an established brand name. The only distinguishing factor was the light cream color imparted by the enrichment mixture containing riboflavin. The cooperation of several supermarkets in the Coastal Plains and Piedmont areas was obtained. The positions of the packages of enriched rice and fortified rice were rotated daily to eliminate any influence which might have been exerted by the position of the packages on the shelf.

In the preliminary tests, in the Coastal Plains, 127 packages of fortified and 129 packages of enriched rice were sold in the 11-day experimental period. The results with the stored rice are given in Table 1.

**TABLE 1**

**Results of sales tests on stored rice**

| Location | Number of 3 lb. packages sold | | | | | |
|---|---|---|---|---|---|---|
| | Brand A long grain | | Brand B long grain | | short grain | |
| | Enriched | Fortified | Enriched | Fortified | Enriched | Fortified |
| Spartanburg | 17 | 18 | 11 | 9 | 11 | 15 |
| Spartanburg | 17 | 17 | 10 | 9 | 14 | 14 |
| Charleston | 80 | 72 | 96 | 94 | 67 | 69 |
| Walterboro | 130 | 114 | 66 | 59 | 48 | 42 |
| | 244 | 221 | 183 | 171 | 140 | 150 |

For the entire period of this test (19–22 days), 567 packages of enriched rice were sold compared to 542 packages of fortified rice. Store personnel reported that there were no comments or complaints from customers in any store.

**Test panels of cooked rice enriched with riboflavin.** Panel members were recruited from students and staff members of Clemson College, 31 from the Coastal Plains, 40 from the Piedmont area of South Carolina and 21 from out of the State.

Samples of fortified and enriched long grain rice were cooked under the same conditions in a rice steamer. A small sample of each was served for paired comparison to panelists in individual booths. The panel members were told that the concern was with appearance rather than texture or flavor. The following questionnaire was supplied with each paired set.

> Two samples of rice are before you. Their appearance may be the same or different.
>
> Are they different? (Circle one) Yes No
>
> If different, which do you prefer?.....

Of the 92 panel members, 13 were not included in the results because they indicated differences in both check sets where no differences existed. It was considered that they were not competent judges.

One group of 48 participants was served the rice under lighting conditions which were considered to be comparable to those

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found in the average dining room. For another group of 31, a 250-watt Mazda lamp was focused directly on the samples, and a preference in color was mentioned as one of the characteristics specifically to be noted. The results are given in Table 2.

TABLE 2

Test panels for cooked enriched and fortified rice

| | No color preference | Preferred fortified rice | Preferred enriched rice |
|---|---|---|---|
| Ordinary lighting | 71% | 26% | 3% |
| Bright light | 63% | 33% | 4% |

While many panel members found differences between the two kinds of rice, they were concerned with texture, taste, seasoning, moistness, fluffiness of grains, etc. Since the participants had been specifically asked to comment on appearance in which color should be a major factor, it is evident that difference in color between the two kinds of rice was not significant enough to cause comment for 63–71% of the panel members. It would appear that the brighter light and the specific request to observe the samples for color served to emphasize the slight color difference for some panelists. Serving the enriched and fortified samples side by side emphasized the slight color difference.

## ENRICHED RICE AND ENRICHED PRECOOKED RICE

**Enriched rice acceptance studies in homes.** In the panel studies, the rice was cooked in a rice steamer without washing before cooking or rinsing or draining after cooking. Homemakers cook rice in a number of different ways with the object of obtaining the fluffy, individually-grained product desired in the South. The points at which the average homemaker would be likely to notice a difference in color between enriched rice and fortified rice would be: as she prepares it for cooking; as she serves it to her family; and as she hears comments of her family on eating the rice.

Thirty-five cooperating homemakers were given two identical 3-pound packages of a standard brand of long grain rice, one of which was enriched, the other, fortified. They were asked to cook them alternately, and to comment on differences, if any, found by them or their families. Of the 35 questionnaires returned:

80% found no difference due to color, of which
57% found no difference at all,
23% found a difference but not in color

20% found a difference in color, of which
14% found more color in the enriched rice
(3% objected to this color)
6% found more color in the fortified rice.

Thus, 86% of the testers did not detect color from riboflavin when it was present. (The 80% finding no color difference plus the 6% finding more color in the fortified rice.) Differences other than color mentioned included such qualities as fluffiness, stickiness, taste, and flavor.

**Acceptance of enriched precooked rice in homes.** Precooked rice is not washed before cooking, or drained or rinsed after cooking by the homemaker, since only the amount of water needed is added. Color contributed by the riboflavin would therefore persist from package to table. The fortified precooked rice had cooking instructions to let the product stand for 13 minutes after adding the boiling water before it was ready to serve. With the enriched rice, a new package with new labeling, it was necessary to allow the rice to stand in boiling water for only 5 minutes before it was ready to serve. Sixteen homemakers, who used precooked rice regularly, were asked to prepare and serve rice alternately from each package.

No comments were received on differences in color between the 2 samples either before or after cooking. Preferences were expressed on the basis of ease of preparation, length of preparation time, tenderness, flavor, etc. Of the 15 questionnaires returned:

67% preferred enriched rice (5 minute)
27% preferred fortified rice (13 minute)
6% expressed no preference.

Analysis of the enriched precooked rice in the laboratory showed that it contained at least 1.2 mg. of riboflavin per pound.

After completion of the above test, the same homemakers were given small packages of the 2 kinds of precooked rice and asked to comment specifically on color. None of the homemakers found the color of the raw or cooked rice to be objectionable.

## SUMMARY

1. Rice enriched with a powdered premix so that it contained the amount of riboflavin specified in the Federal standard sold as well as rice with no riboflavin added. In two separate marketing trials, a total of approximately two tons of rice (50% enriched, 50% fortified), packaged in 3-pound cellophane bags, and displayed without preference to either type, was sold in five supermarkets in South Carolina, three of which are located in the coastal area where rice consumption is very high. No consumer complaints or comments were received.

2. In panel studies using cooked rice, under ordinary lighting, 71% of the panel members had no color preference for either enriched rice or fortified rice. Under a 250-watt Mazda lamp, 63% of the panelists had no color preference between the two types of rice. The paired comparison method was used in both tests.

3. Of the homemakers preparing the two types of rice in their homes, 80% indicated that they found no difference due to color; of the remaining 20%, 6% found more color in the fortified rice, and 14% found more color in the enriched rice. Only 3%, in the latter group, objected to the color.

4. Homemakers preparing enriched and fortified precooked rice indicated no awareness of color: 67% preferred the enriched rice; 27% preferred the fortified rice, 6% expressed no preference. The basis for the preferences was on qualities other than color. When these same homemakers were asked to comment on color specifically, none found it objectionable.

5. From these studies, it appears that consumers will readily accept rice enriched by the powdered premix method whereby riboflavin as well as thiamine, niacin, and iron is added to the level specified in the Federal standard.

LITERATURE CITED

1. Che, Kung Pei, and Tung Ta-Cheng. The rice enrichment project in Taiwan, China 2. Observation on the applicability of "premix" enriched rice to social customs in Taiwan. *J. Formosan Med. Assoc.*, **54**, 113 (1955).
2. Federal Register, Vol. 23, Title 21, page 1170, February 25, 1958.
3. Lease, E. J., Brunson, Julia P., and McDill, Janie. Rice enrichment in South Carolina. *The Rice Journal*, **58**, 14 (1955).
4. Memorandum dated November 6, 1956 to J. E. Barr, Chief, Inspection Branch, USDA, Washington, D. C. from W. D. Smith, Officer in Charge, Grain Division, USDA, New Orleans, Louisiana.
5. Pollack, Herbert. Studies on nutrition in the Far East. III. Clinical indicator signs of nutritional insufficiencies before and after enrichment of rice with synthetic vitamins. *Metabolism, Clinical and Experimental*, **5**, 231 (1956).
6. Proposed Definition and Standard of Identity for Enriched Rice. Federal Register Vol. 21, Title 21, page 10412, December 28, 1956. Federal Register Vol. 22, Title 21, page 6887, August 27, 1957.

# Storage Characteristics of Potato Granules[a]

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(Manuscript received May 31, 1958)

THE STORAGE BEHAVIOR of potato powder and granules has received much attention *(1, 7)*. This study covers storage characteristics of potato granules produced commercially in the American Potato Company's Idaho Falls plant in March, 1956. Storage at 98.6° F. was studied over a period of 212 days, terminating in October, 1956. Room temperature storage tests had been carried on for a period of 777 days at the time the most recent series was opened on May 8, 1958. Storage at 40° F. is still in progress at the time this paper is being written.

## MATERIALS AND METHODS

Moisture contents of 10%, 8%, 6% and 4% were obtained by varying drying conditions for short periods of time. Sulphite contents expressed as $SO_2$ were approximately 200 p.p.m. on all samples. Optical Density x 1000 was approximately 69.0 on all samples. Five p.p.m. butylated hydroxyanisole was added to a portion of each moisture level by first grinding pure BHA with granules to make a 10,000 p.p.m. concentration. Portions of this concentrate were weighed on an analytical balance and then added to each test tin and thoroughly mixed. All samples were hermetically sealed in 2 11/16 x 3¼ in. tins. Nitrogen packing was accomplished by piercing the lids of the sealed tins to make an opening about 1/16 x 1/32 in., drawing a full commercial vacuum, and bringing back to room pressure with pure nitrogen. Immediately upon removing from the gassing chamber, the openings were soldered. Storage at 98.6° F. was in a constant temperature incubator. Storage at room temperature averaged 75° F. and varied between 40° F. and 106° F. Storage at 40° F. was in a constant temperature refrigerator.

Samples were examined periodically by a trained panel. They were evaluated for color both visually and by Optical Density determinations on 1% solutions, 50 mm. cell path and 420 mμ filter, using a Lumetron Colorimeter and extracting with a 10% salt solution. Aroma of the dried product was evaluated organoleptically. Mashed potatoes were made by adding the granules to four times their weight of water at 200° F. These potatoes were evaluated for flavor, texture, color and aroma by the trained panel. Tests at all storage temperatures and moisture levels were continued until the products were considered unsalable or until the samples were exhausted. Room temperature and refrigeration tests are still in progress after 777 days.

## RESULTS AND DISCUSSION

**Role of moisture content in storage of potato granules at 98.6° F.** Figure 1 shows the nonenzymatic browning rate at 98.6°F. storage. In all cases, this browning was a straight line function with time on air packs.

These data show that the browning rates were more rapid in the case of nitrogen packs and the difference increased with increase in moisture level.

The indicated rate of browning is as follows:

| Moisture content | O.D. units increase/ day x 1000 | Ratio |
|---|---|---|
| % | | |
| 4 | 0.154 | 1.0 |
| 6 | 0.555 | 3.6 |
| 8 | 0.800 | 5.2 |
| 10 | 3.667 | 23.8 |

4% moisture samples were considered borderline color after 212 days at 98.6° F.
6% moisture samples were considered borderline color after 152 days at 98.6° F.
8% moisture samples were borderline color after 75 days at 98.6° F.
10% moisture samples were unacceptable color after 75 days at 98.6° F.

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Illinois, May 28, 1958.

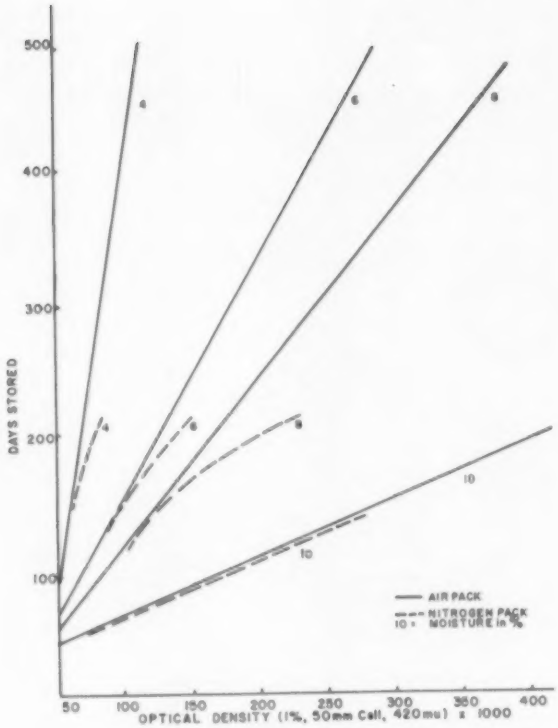


**Figure 1. Changes in optical density vs. time for potato granules packed under varying moisture and atmosphere.**

In all cases, visual color grading of the dry products followed the Optical Density ratings. This was also true in color judging of mashed potatoes.

At the end of only 19 days' storage, the 4% moisture control sample had a definite rancid aroma. Rancidity was noted in the 6% control at 152 days and in the 4% nitrogen pack at 212 days. All other samples were free of rancidity.

In the 8% and 10% moisture ranges, browning made the product unacceptable before any rancidity developed.

The two types of storage deterioration materially affected the flavor of mashed potatoes made from these storage granules. Nonenzymatic browning produced a caramelized aroma and taste which made the products unacceptable flavorwise at the same time they were unacceptable colorwise. Rancidity in flavor followed rancid aroma, but it was felt that granules with a slight rancid aroma in the dry form would be acceptable when made into mashed potatoes, except to those with trained tastes.

There was no evident texture deterioration in any granule samples, including those completely unacceptable from color, aroma, or flavor standpoints.

**Room temperature storage of potato granules (75° F.).** Table 1 shows a unique but uniform color pattern when potato granules were stored at an average room temperature of 75° F.

In all cases, there was a gradual color improvement for the first 200 to 300 days, followed by a slight gradual darkening which was still appreciably better than the starting product after 489 days. The series opened after 777 days storage showed a still greater color improvement.

In all cases, except the 8% series, the color improvement became more pronounced as moisture increased during the first 300 days. At 489 days and 777 days, there were no significant differences between the different moisture levels.

In all except the 6% series, color was not closely related to the presence or absence of BHA or nitrogen. The nitrogen pack at 6% moisture did not improve at a rate comparable to the other packs.

Every sample opened after 777 days storage was equal to or better than current production in visual appearance.

At 212 days, all samples were judged to have a slightly undesirable dry aroma which was not due to rancidity. Rancidity was first noticed in the 4% moisture control at 309 days and in the 4% nitrogen pack at 777 days. The unprotected 6% moisture control showed slight rancidity at 489 days but none was detected after 777 days. All other samples were free of rancidity, but the aroma of nitrogen packs was generally preferred.

A slight rancid taste was detectable in the same samples which had rancid aroma. It was the opinion of the panel that even these samples made into mashed potatoes with milk, butter, salt, etc., would be perfectly acceptable to all but trained tasters.

As in previous tests, no texture deterioration was noted in any sample.

**Refrigerated storage of potato granules (40° F.).** Table 2 shows Optical Density x 1000, dry reflectance values, and visual color rankings for samples stored 777 days at 40° F.

Table 2 shows that 15 of 16 samples were considerably lower in Optical Density than the 69.0 of the starting material. All dry reflectance values are in the range considered "very good."

Visual differences were easy to detect. Consistently, air packs were superior. Visually, the combination of

TABLE 1

**Color of potato granules stored at 75° F.**

| Storage time in days | Moisture content | Control | Optical density extracted color x 1000 | | |
|---|---|---|---|---|---|
| | | | Granules + 5 p.p.m. BHA | Granules + $N_2$ pack | Granules + $N_2$ pack + 5 p.p.m. BHA |
| | % | | | | |
| 0 | 10 | 69.0 | 69.0 | 69.0 | 69.0 |
| 75 | 10 | 64.0 | 66.0 | 69.0 | 64.0 |
| 212 | 10 | 33.4 | 35.1 | 35.1 | 35.4 |
| 309 | 10 | 43.5 | 44.6 | 46.0 | 40.3 |
| 0 | 8 | 69.0 | 69.0 | 69.0 | 69.0 |
| 309 | 8 | 44.6 | 41.8 | 49.3 | 48.9 |
| 489 | 8 | 44.3 | 47.2 | 51.5 | 52.0 |
| 777 | 8 | 34.4 | 30.3 | 20.9 | 43.6 |
| 0 | 6 | 69.0 | 69.0 | 69.0 | 69.0 |
| 309 | 6 | 43.2 | 37.9 | 55.0 | 36.9 |
| 489 | 6 | 45.4 | 50.0 | 53.5 | 53.5 |
| 777 | 6 | 28.3 | 16.5 | 27.6 | 31.7 |
| 0 | 4 | 69.0 | 69.0 | 69.0 | 69.0 |
| 309 | 4 | 52.0 | 44.6 | 52.0 | 50.5 |
| 489 | 4 | 47.5 | 45.4 | 55.0 | 54.5 |
| 777 | 4 | 29.3 | 31.7 | 29.3 | 34.1 |

**TABLE 2**

**Potato granules stored 777 days at 40° F.**

| Moisture | Code | Optical density x 1000 | Dry reflectance | Visual rank |
|---|---|---|---|---|
| % | | | | |
| 10 | CA | 60.0 | 84.0 | 2 |
| 10 | CN | 58.0 | 83.5 | 3–4 |
| 10 | BA | 52.5 | 83.5 | 1 |
| 10 | BN | 52.5 | 83.0 | 3–4 |
| 8 | CA | 49.4 | 84.5 | 2 |
| 8 | CN | 59.5 | 84.5 | 3 |
| 8 | BA | 52.5 | 85.0 | 1 |
| 8 | BN | 51.5 | 83.5 | 4 |
| 6 | CA | 59.5 | 83.5 | 2 |
| 6 | CN | 60.5 | 83.5 | 3–4 |
| 6 | BA | 60.5 | 85.0 | 1 |
| 6 | BN | 73.0 | 83.5 | 3–4 |
| 4 | CA | 52.5 | 83.5 | 1–2 |
| 4 | CN | 52.5 | 83.5 | 3–4 |
| 4 | BA | 52.5 | 85.0 | 1–2 |
| 4 | BN | 50.5 | 83.5 | 3–4 |

CODE KEY: B = Samples containing 5 p.p.m. BHA; C = Controls with no antioxidant; N = Nitrogen pack (less than 2 % oxygen); A = Air pack.

BHA and air gave superior color results. Dry reflectance values correlate better with visual color than Optical Density does, but improvement in both procedures is required.

The only air pack control free of rancidity after 777 days was the 10% moisture sample. Nitrogen pack controls were considered borderline for rancidity at the 6% and 8% moisture levels but were free of rancidity at 4% and 10% levels.

A "gassy" aroma was detected on all samples at 10% moisture except the control.

Completely bland aroma was found in BHA packs combined with air or nitrogen at the 4% and 6% moisture levels.

No off-flavors were detected in any samples except the air controls at 6% and 8% moisture levels.

As in all storage tests, no texture changes were detectable.

## SUMMARY

BHA at a concentration of 5 p.p.m. was very effective in preventing the development of rancidity. At 98.6° F., 5 p.p.m. BHA gave complete protection against rancid flavor and aroma at all moisture levels tested for the test duration of 212 days. At room temperature (75° F.) storage, some slight staling was first noticed after 309 days in the 4% moisture samples containing BHA or nitrogen. At this time, the control was definitely rancid. After 489 days at 75° F., samples with 5 p.p.m. BHA were definitely superior to controls in aroma and flavor but not quite as good as nitrogen packs or combinations of nitrogen and BHA. A slight but not significant color improvement was usually associated with samples containing BHA. After 777 days at room temperature, all BHA packs were free of rancidity.

Nitrogen packing to an oxygen content of less than 2% was also effective in preventing development of rancidity. At 98.6° F. storage, nitrogen packing gave complete protection against rancid aroma and flavor at all moisture levels during the 212 days test. At room temperature storage, nitrogen packs gave perfect protection up to 489 days. Even then, there was no detectable rancidity, but combinations of nitrogen and BHA were preferred in aroma and flavor. After 777 days, the 4% moisture nitrogen pack was rancid, but in other moisture ranges, nitrogen packs or combinations of nitrogen and BHA were superior with no trace of rancidity.

If storage temperatures could be positively controlled at room temperature or below, excellent shelf life would result at moistures as high as 10%, even in air pack with no antioxidants. Since such optimum conditions do not apply in most cases, moisture content becomes a critical factor. If continued high temperatures of 98.6° F. or above may be encountered, moisture contents must not be far above the 6% level. As the chances of nonenzymatic browning decrease by moisture reduction, the chances of development of rancidity greatly increase. Either an efficient nitrogen pack (less than 2% oxygen) or 5 p.p.m. Butylated Hydroxyanisole greatly extends the shelf life at the lower moisture levels. After prolonged storage where color has not deteriorated, it is indicated that the nitrogen pack is generally slightly better than 5 p.p.m. BHA pack in flavor but that a combination of both means of protection is superior to either alone when all factors are considered. Effective nitrogen packs, of course, require special, more costly packaging.

Nitrogen packs consistently are detectably darker than corresponding air packs. On the basis of the above Optical Density data, this is undoubtedly due more to the lessening of bleaching than to some detrimental effect of the inert gas. The above data all show a definite "bleaching" effect under all conditions tested, providing nonenzymatic browning is not allowed to occur.

Shelf life of properly protected potato granules can be considered indefinite if storage temperatures are kept at room temperature or below. Common storage temperatures, even in the hottest areas of the country, are far below the constant 98.6° F. used in part of this work.

## LITERATURE CITED

1. BURTON, W. G. Mashed potato powder. III. The high temperature browning of mashed potato powder. *J. Soc. Chem. Ind.*, **64**, 215–18 (1945).
2. BURTON, W. G. Mashed potato powder. IV. Deterioration due to oxidative changes. *J. Soc. Chem. Ind.*, **68**, 149–51 (1949).
3. HENDEL, C. E. *Potato Processing*. Chapter XII. (In press). Avi Publishing Co., Westport, Connecticut.
4. HENDEL, C. E., BAILEY, G. F., AND TAYLOR, D. H. Measurement of non-enzymatic browning in dehydrated vegetables during storage. *Food Technol.*, **4**, 344–47 (1950).
5. HENDEL, C. E., BURR, H. K., AND BOGGS, M. M. Factors affecting storage stability of potato granules. Western Regional Research Laboratory, Albany, California (U. S. Dept. Agr.) *AIC–303*.
6. HENDEL, C. E., SILVEIRA, V. G., AND HARRINGTON, W. O. Rates of nonenzymatic browning of white potato during dehydration. *Food Technol.*, **9**, 433–438 (1955).
7. LEGAULT, R. R., TALBURT, W. F., MYLNE, A. M., AND BRYAN, L. A. Browning of dehydrated vegetables during storage. *Ind. Eng. Chem.*, **39**, 1294–99 (1947).

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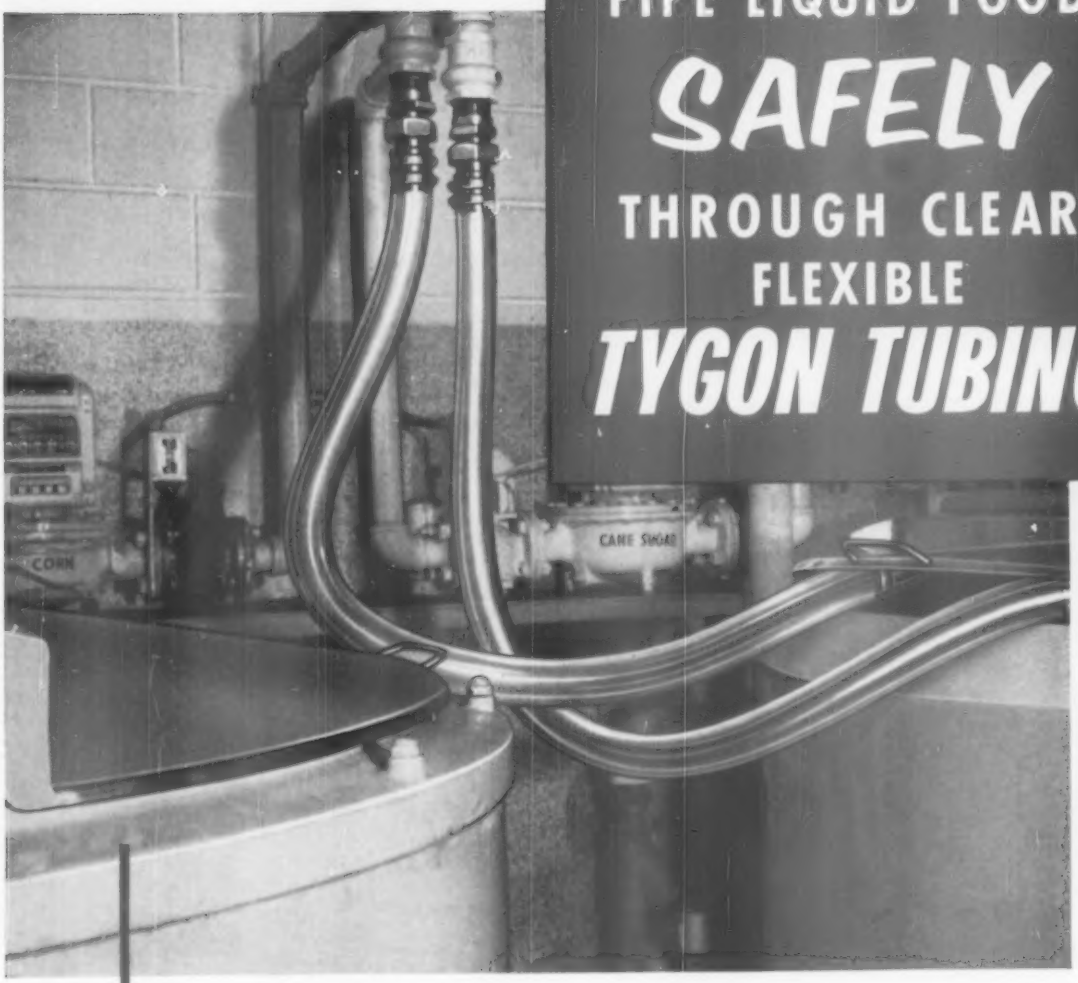


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# Modern Baking Concepts for Troop Feeding: Development of the Instant Bread Mix[a]

**Samuel A. Matz, Jason Miller,[b] and Julius Davis**

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(Manuscript received May 13, 1958)

A BREAD-TYPE FOOD is an indispensable item in every Army ration. In the United States, and in many overseas posts during peacetime, bread is procured from commercial bakeries in the area. In wartime, especially in forward areas, this mode of supply is not feasible. The soldier must either be supplied preserved bakery products such as crackers or canned bread, or fresh bread from an Army bakery located near the point of consumption.

## PRESERVED BAKERY PRODUCTS—SOME LIMITATIONS

Crackers are a stable, easily transported bread substitute, but they are not desirable for constant consumption because their acceptability declines rapidly. A morale problem may eventually be the result. This is unfortunate because crackers possess many desirable characteristics from the ration standpoint. In addition to being extremely resistant to both texture and flavor staling, they are economical, easy to dispense, and fairly simple to package. They are now used in certain operational rations in spite of their drawbacks, but it would be more desirable to use bread if it were possible.

Canned bread is the second alternative. More acceptable as a constant diet than are crackers, canned bread is less desirable than fresh for a number of reasons. Although it remains edible after many months of storage at elevated temperatures, its hedonic rating declines constantly throughout this period. Table 1 compares the hedonic ratings on a 9-point scale of canned bread samples stored at 100° F. for varying periods. There is little doubt that much of the bread stored for 9 months, or even less, would be discarded by the intended consumer.

Canned bread also presents logistical problems. One problem is weight. The container, in itself, represents about one-third to one-half of the gross weight. About 35% of the net weight is due to water, as opposed to the 12 to 14% usually found in flour. Another problem is the disposal of the empty cans. If the cans were to be left on the ground in battle areas, they might very well provide the enemy with valuable information as to the strength and disposition of our forces. The alternative, burying the cans, is a time-consuming practice and may be impossible when enemy action is imminent. Some of the logistical difficulty might be overcome by packaging the bread in hermetically sealed plastic envelopes. Such envelopes, as a matter of fact, are under study and experimental work has been active.

Dehydrated bread has also been considered as a possible means of supplying bread to the soldier. Bread can be reduced very readily to less than 5% moisture without much permanent damage to any of its inherent physical properties. Unfortunately, no method of rapid rehydration has been devised, or even visualized, which could be applied during military operations in the field. Dehydrated bread is no longer receiving serious emphasis.

To summarize, it can be said that preserved bakery products are probably indispensable for certain applications but are undesirable for general use. It would be far more desirable to bake bread near the points of consumption. Bread ingredients are much more stable than the product itself, they contain less moisture, and they require less expensive packaging.

## THE PRESENT SITUATION IN FIELD BAKING

Two types of installations, one mobile and the other portable, are available at present for baking near forward areas. The mobile field bakery is manned by 3 operating platoons and a headquarters unit. Nearly 250 men are involved. About 50 vehicles are required for transporting this installation. The specialized equipment alone weighs nearly 50 tons. Partly as a result of its large size, the mobile field bakery is fairly efficient and is capable of supplying bread to 100,000 men. However, it has disadvantages. Only 3 units each of certain specialized equipment are present. If a trailer transporting one of these pieces of equipment is lost through enemy action or by accident, the capacity of the bakery is immediately reduced by one-third. In addition, the coordinated transportation and erection required are very difficult to achieve in wartime.

For defense in atomic warfare, the Army may be envisioned as units of about 2,000 men, completely mechanized, highly dispersed, and moving rapidly

[a] Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists held in Chicago, Illinois, 25–29 May 1958.

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TABLE 1

**Effect of the time of storage at 100° F. on the acceptability of canned bread**

| Storage time at 100° F. | Hedonic rating[1] |
|---|---|
| *Months* | |
| 0 | 6.06 |
| 3 | 5.64 |
| 6 | 5.28 |
| 9 | 5.04 |
| 12 | 4.94 |

[1] 5.0 means neither *like* nor *dislike*.

over long distances. These units would be completely separated, in a physical sense, from command headquarters. The impracticability of transporting a perishable, light weight, and fragile foodstuff to 50 units (100,000 men) from a central bakery every day seems self-evident.

The second alternative for supplying fresh bread is to bake it within the basic unit. At present, no efficient unit exists for accomplishing this alternative. It is true that a so-called portable bakery is described in the field manuals. For use under the new concept, the portable bakery, which involves much manual handling of the doughs, cannot be regarded as adequate. Persons who have operated this equipment indicate that even under the best of conditions less than 250 pounds of dough per day per operator can be made. Under the less favorable conditions of nuclear combat, the output can be expected to drop sharply. In any case, it can be easily imagined what kind of product would be supplied by this equipment.

Although the *ideal* bakery for the Army of the future does not exist, the recent development of continuous bread making processes suggests a possible approximation of one. It should be borne in mind, however, that any process embodying the fermentation steps necessary in the conventional bread making procedure has certain inherent disadvantages for field use. For example, the dough must be maintained at controlled temperatures for varying periods—which means that fairly large space will be occupied by an insulated room with controlled heating equipment. If the fermentation steps could be eliminated, a bakery for supplying 2,000 men with bread could conceivably be designed around a continuous mixing and dough forming apparatus and one or more ovens.

This is where chemical leavening systems come into the picture. The QMFCI project to develop an instant bread mix based on chemical leavening systems was begun, in fact, to provide a basis for the design of such a bakery. This paper reports the experimentation that resulted in the development of an instant bread mix capable of meeting the requirements of continuous bread making, under combat conditions of the future, in a field bakery.

## MATERIALS AND METHODS

The flour used was a good commercial grade of hard wheat flour, bakers' patent, analyzing 12.06% protein, 0.48% ash, and 12.94% moisture. In some cases, the same flour, dehydrated to 6.0% moisture, was used. No damage to baking properties resulting from the dehydration could be observed. The yeast was compressed bakers' yeast, never more than 7 days old. Nonfat dry milk was the high heat type produced for bakery use. Shortening was 100-hour vegetable shortening. The leavening acid was 95% glucone-delta-lactone coated with 5% calcium stearate.

From the nutritional standpoint, it was considered desirable, though not essential, to retain the formulation of standard Army bread, so far as possible. Bread baked by conventional methods for comparison purposes had the formula shown in Table 2.

Conventional bread was prepared by suspending the yeast in a portion of the water and placing it in the McDuffee mixing bowl with all the remaining ingredients and the rest of the water. The dough was mixed for one minute at slow speed and 7 minutes at second speed of a three-speed mixer. The loaves were scaled at 20½ ounces into individual fermentation jars and allowed to ferment 2 hours. The doughs were then punched and given a 20-minute rest period at 85° F. before molding. The loaves were proofed for 60 minutes at 100° F. and 95% R.H. after molding and then were baked for 30 minutes at 425° F. in a gas fired reel oven.

**TABLE 2**
**Standard Army bread formula**

| Ingredient | Per cent of flour weight |
|---|---|
| Flour | 100.0 |
| Sucrose | 5.5 |
| Nonfat dry milk | 6.0 |
| Salt | 1.0 |
| Shortening | 5.0 |
| Compressed yeast | 2.5 |
| Water | 65.0 |

**TABLE 3**
**Instant bread mix formulation**

| Ingredient | Per cent of flour weight | Grams |
|---|---|---|
| Flour | 100.0 | 700.0 |
| Sucrose | 5.5 | 38.5 |
| Nonfat dry milk | 6.0 | 42.0 |
| Salt | 1.0 | 7.0 |
| Shortening | 5.0 | 35.0 |
| Soda | 3.5 | 24.5 |
| Delta-lactone of Gluconic acid | 9.0 | 63.0 |
| Lyophilized flavor broth | 4.0 | 28.0 |
| | 134.0 | 938.0 |

Flavor broth

| | |
|---|---|
| Di basic sodium phosphate (0.1M) | 1,000 ml. |
| Sucrose | 100 g. |
| Nonfat dry milk | 50 g. |
| Compressed yeast | 50 g. |

In papers presented elsewhere, the development of a chemically leavened bread *(3)* flavored with cell-free fermentation broths *(2)* was described. Formulas in use at the beginning of the series of experiments described in the present paper are shown in Table 3. The cell-free broth was prepared by fermenting sucrose in the presence of nonfat dry milk solids dissolved in 0.1M dibasic sodium phosphate with *Saccharomyces cerevisiae*. The quantities of each component of the broth are also shown in Table 3. The quantities of auxiliary ingredients in the chemically-leavened formula were selected by analogy with Army bread formulas. Method of mixing for the chemically-leavened bread was also the same as for the conventional bread.

Volume determinations were made by the usual rape-seed displacement method. The pH was determined electrometrically 10 minutes after mixing 10 g. of crustless crumb in 100 g. of distilled water.

## RESULTS AND DISCUSSION

Development of a flavor for use with the chemically-leavened bread including the results of experiments aimed toward improving the flavoring constituent has been previously reported *(3)*. The formula for the broth preparation has already been shown. The technique of preparation may be summarized as follows: the broth was fermented at about 100° F. for 4 hours and then centrifuged to remove the yeast. During fermentation, the pH of the medium dropped from 7.6 to about 6.1. Effort to improve the flavor has continued. In one experiment, an apparatus was set up to ferment the broth at a constant pH. An automatic titrating device was used to add quantities of 5 *N*. sodium hydroxide solution continuously in quan-

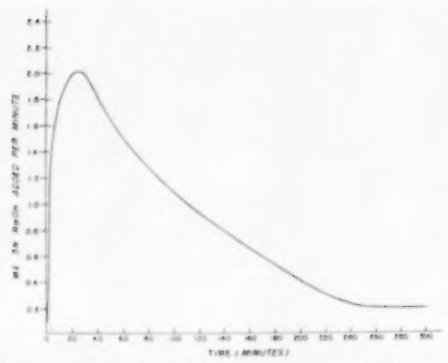

Figure 1. Rate of addition of sodium hydroxide required to maintain a constant pH of 7.4 during the period of fermentation.

tities sufficient to maintain a constant pH of 7.4. Since the rate of addition of sodium hydroxide parallels the rate of fermentation, the curve in Figure 1 also illustrates the rate of fermentation. The broth was centrifuged in the normal manner. Half was treated with ion exchange resins to remove the additional sodium. These broths were used as flavoring agents for the chemically-leavened bread. An evaluation of the bread showed the broth fermenting at constant pH, both with and without ion exchange treatment, had less of the desirable taste characteristics than did the control broth. It was concluded that the products of the metabolism of yeast at pH 7.4 are less desirable for a bread flavor than those at uncontrolled pH from 7.6 to 6.1.

A second experiment was conducted to increase the solids content of the broth and thus to facilitate drying. Four broths were prepared: a control with the composition shown earlier, one with two times the amount of dry materials, one with three times, and one with four times as much dry materials. The compositions of the broths are illustrated in Table 4. These were fermented, centrifuged, and used in the usual manner. With the exception of the control, each was used at two levels of concentration in the chemically-leavened mix. The results shown in Table 5 indicate that the broth having 3 times the initial concentration of the original formulation—300 g. sugar, 150 g. nonfat dry milk, and 150 g. compressed yeast—furnished the loaf of preferred flavor. Table 5 also indicates that when the higher concentration broths were diluted, they gave the same preference as the lowest concentration broth. The change in pH with increasing fermentation time for each of the broths is shown in Figure 2.

It is very desirable to have a dry flavor incorporated in a complete mix. Several methods of drying the centrifuged broth were tried. Lyophilization of the broth gave the best results. Broths dried at 28-in. vacuum at room temperature possessed slightly less flavoring capacity than did lyophilized broth. Spray drying gave about the same results as vacuum drying.

TABLE 4

Effect of broth ingredient composition on bread flavor

| Broth | 0.1M. $Na_2HPO_4$ | Sucrose | Nonfat dry milk | Compressed yeast |
|---|---|---|---|---|
| | *ml.* | *grams* | *grams* | *grams* |
| 1 x | 1000 | 100 | 50 | 50 |
| 2 x | 1000 | 200 | 100 | 100 |
| 3 x | 1000 | 300 | 150 | 150 |
| 4 x | 1000 | 400 | 200 | 200 |

TABLE 5

Acceptability of chemically-leavened bread

| Broth | Dilution | Hedonic rating | Dilution | Hedonic rating |
|---|---|---|---|---|
| 1 x | 0 | 6.2 | 0 | 6.2 |
| 2 x | 0 | 6.8 | 1/2 | 6.5 |
| 3 x | 0 | 7.2 | 1/3 | 6.5 |
| 4 x | 0 | 5.5 | 1/4 | 6.2 |

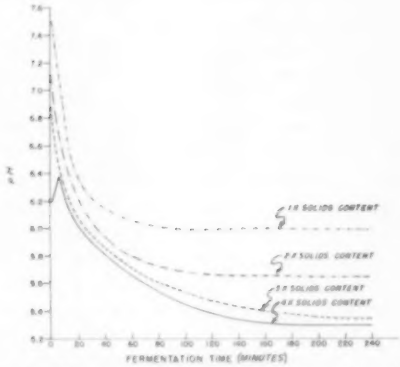

Figure 2. Effect of fermentation time on pH by broths containing various concentrations of solids.

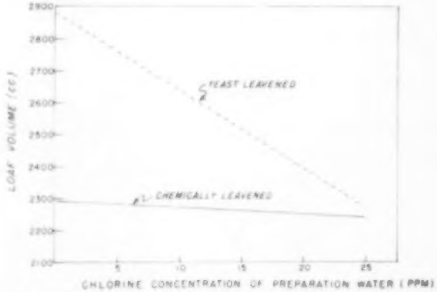

Figure 3. Effect of chlorine concentration on water used in preparing yeast leavened and chemically leavened bread.

Although the artificially flavored, chemically-leavened bread performs satisfactorily in laboratory tests, it is necessary to know how it will react to some of the untoward influences encountered during field use. Water available in the field is usually purified with chlorine. The concentration of this chemical may vary considerably for one reason or another. The effect of varying concentrations of chlorine in the preparation water of yeast-leavened bread and of chemically-leavened bread on their volumes is shown in Figure 3. These results show that chemically-leavened bread doughs are much more resistant to the effect of excess chlorine in the water than yeast-leavened bread doughs. This is most desirable for a

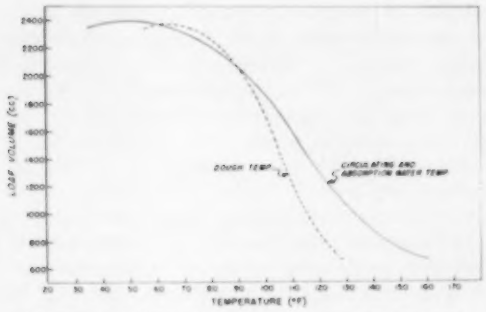


**Figure 4. Effect of temperature on loaf volume.**

product destined for field use. Odor and flavor of the chlorine becomes detectable, however, at the higher concentrations used here.

Temperature of the water is another variable not always subject to precise control in the field. Figure 4 gives the loaf volume results of an experiment in which the water used to prepare chemically-leavened bread was varied over a wide range. It is clear that the mix can be prepared with water having any temperature likely to be encountered. The loaf volumes show an appreciable decline at 90° F. and above.

Since the measurement of water and mix at the bakery will, if manually done, be subject to the usual human vagaries and, if mechanically performed, be affected by uncertainties of adjustment, it was considered to be of interest to find the response of the mix to changes in the proportion of water to mix. Loaf volumes of the resulting loaves are shown in Table 6. Again we see a rather astonishing flexibility; the loaves retain good volume even though the water-to-mix proportion is varied over a wide range.

**TABLE 6**

**Effect of variation of absorption water on loaf volume**

| | Per cent absorption water based on flour weight | | | | |
|---|---|---|---|---|---|
| | 45% | 50% | 55% | 60% | 65% |
| Loaf volume (cc.) | 2080 | 2375 | 2275 | 2065 | 1950 |

A variety of baked goods is desirable for troop feeding, and it would be unsound logistically to have to supply ingredients for other yeast-leavened goods when bread ingredients are eliminated through use of a complete mix. Therefore, the versatility of the instant bread mix was tested by preparing several varieties of products from it.

Figure 5 shows the products of instant bread mix. The white bread had the formulation shown in Table 3. The hot rolls had the same formulation and weighed about one and one-half ounces each. The wheat bread used the basic mix with the addition of 100 g. wheat base *(1)*. The sesame egg twist had 2½ egg yolk solids based on the flour in the basic mix. It was braided, washed with milk and dipped in sesame seeds before baking. The streussel coffee cake was made with 2½% additional egg yolk solids and then covered with a

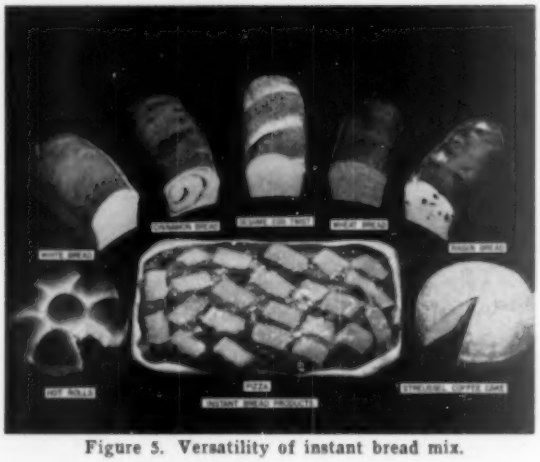


**Figure 5. Versatility of instant bread mix.**

streussel topping. The cinnamon bread also had the extra 2½% egg yolk solids. It was rolled out, washed with egg yolk, and lightly sprinkled with a cinnamon-sugar mixture and then rolled. The pizza, using the basic mix, was partially baked on one side, turned over, and covered with the sauce and cheese. It was baked until the cheese melted. The preparation of the raisin bread caused some difficulty. Bleached raisins did not perform satisfactorily. Even when the raisins were soaked for 4 hours prior to use, they still caused decreased volume in the bread when incorporated either at the beginning or the end of the mixing period. The water in which the raisins were soaked caused a similar volume reduction. Use of 30% unbleached raisins on a flour weight basis in the pictured loaf caused only a slight volume decrease. The raisins were incorporated at the end of mixing.

The field bakery utilizing this chemically-leavened bread mix is visualized as consisting of a continuous mixer which will also form the dough pieces into loaves. It will require just 3 men to operate, on overlapping 10-hour shifts for a total of 18 hours per day to supply 8 ounces of bread and 4 ounces of cake per day to each of 2,000 men. The entire unit could be transported on one 2½-ton truck.

## SUMMARY

An instant bread mix developed by the Quartermaster Food and Container Institute has been shown to be versatile, capable of being prepared under a wide range of conditions, and to have good sensory characteristics. It could be used in a small simplified field bakery designed around a continuous mixer. This new bakery should eliminate, without any loss in baking efficiency, many difficulties which presently attend the preparation in the field of baked goods for small diversified combat units.

## LITERATURE CITED

1. Cryns, J., Calloway, D. H., Bollman, M., and Larsen, R. A. Heat stabilized wheat base. *Cereal Chem.*, 11, 5 (1953).

2. DAVIS, J., AND MATZ, S. A. Factors influencing the development of bread flavor precursors in yeast fermented media. Presented at the forty-third annual meeting of the American Association of Cereal Chemists. April, 1958.

3. MILLER, J. A., MCWILLIAMS, C. S., AND MATZ, S. A. Development of the leavening system for an instant bread mix. Presented at the forty-third annual meeting of the American Association of Cereal Chemists, April, 1958.

# Functional Properties of Vital Gluten*

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(Manuscript received May 31, 1958)

THE FOOD TECHNOLOGIST is frequently confronted with the lack of desirable physical properties in a food product and/or the unwanted presence of objectionable features. This is a dilemma common to many technologies. It is possible to view these problems from the standpoint of an engineer rather than a chemist or biologist. This approach is useful when considering food applications for vital gluten because this material serves two purposes: (1) as a convenient source of concentrated protein (commercially available at guaranteed protein levels up to 80%, moisture-free basis) and (2) as an aid in solving the engineering problems of a food product because of its many functional properties.

Vital wheat gluten (sometimes called gum gluten) is the protein fraction of wheat flour. It is separated by using water to wash away the starch and solubles and then dried at low temperature; finally it is pulverized and sized. Vital gluten is a creamy-tan powder which possesses the features of fresh washed gluten when reconstituted with water. Its high protein content is readily recognized from the guaranteed analyses listed by the established manufacturers. This paper is primarily concerned with the functional properties. It will present either numerical values for them or suitable comparative measurements.

## PROTEIN FORTIFIER

The high protein content of vital gluten (available at 80% protein, moisture-free basis) obviously leads to its use in raising the protein content of a food product to a desired level. It permits a minimum numerical displacement of those other ingredients which contribute to the individuality in a product. Equally as important is the fact that vital gluten is bland in flavor and odor. It is completely compatible with any food product in which it is used.

* Presented at the Eighteenth Annual Meeting of the Institute of Food Technologists, Chicago, Ill., May 26, 1958.

## HYDRATION AGENT

The behavior of vital gluten as a hydration agent is to a degree independent of the doughing property with water. This function should therefore be considered separately. A fully hydrated vital gluten-water dough will contain 60–65% moisture. Moisture pick-up begins immediately as the two materials are mixed; 20 to 30 minutes or more are needed before swelling or hydration is complete, depending on the type of mixing. Powdered devitalized gluten will hold about the same amount of water, as shown in Table 1.

TABLE 1

**Moisture content and dough quality after one hour of hydration time under water**

| Vital/devitalized gluten, 6% moisture, grams | Hydrated weight, grams | % Moisture held, basis bone dry weight of gluten | Doughing quality |
|---|---|---|---|
| 100/0 | 278 | 189 | Good |
| 67/33 | 287 | 205 | Poor |
| 50/50 | 292 | 210 | Crumbly |
| 33/67 | 292 | 210 | Crumbly |
| 0/100 | 285 | 202 | Mush |

The high amount of water held by and in the presence of devitalized gluten is attributed to the combination of absorbed moisture plus interstitial water in much the same way that sand holds water. The moisture-holding property of gluten is not, however, solely a function of its doughing characteristic. It may be considered a separate property.

A typical application of this property is in the case of bread. A loaf baked with flour containing 3% added vital gluten was shown by Dubois and Cotton *(1)* to have 37.4% moisture as compared with a control at 36.3%. This higher moisture content means longer shelf life, because the bread remains soft for a longer time.

Winston *(3)* showed that adding vital gluten to macaroni products increased the volume and weight

on cooking, and decreased the loss of dissolved solids in the cooking water. The result was an improvement both as to texture, flavor and palatability. Retention of moisture can mean retention of flavor and other factors associated with the moisture, with multiple benefits for many types of food products.

## OIL ABSORBER

The natural fat content of wheat flour is very tightly bound in the gluten separated from it. For example, only partial recovery is accomplished in the Soxhlet extraction with ethyl ether. To a degree, this capacity to hold fat also applies to added fat. The simplest system to study consists of only the 2 components, fat and vital gluten. When powdered vital gluten is mulled with increasing proportions of oil, the vital gluten becomes progressively more bulky.

TABLE 2

**Absorption of corn oil by dry vital gluten**

| Sample No. | % Corn oil basis gluten weight | Appearance |
|---|---|---|
| 1 | 0 | Normal |
| 2 | 5 | Fluffy, trace of oiliness |
| 3 | 10 | Fluffy, trace of oiliness |
| 4 | 15 | Very fluffy, noticeably oily |

To the above samples was added 200% water, basis gluten weight, and a dough formed with stirring. All samples hydrated readily, with a slightly slower rate of hydration as the oil content increased. After a rest period, to allow complete hydration (under water to prevent drying), all doughs were rated as strong. Sample 4 with 15% fat was slightly less strong than the others, suggesting dough strength woud decrease with further increases in oil.

It is interesting that prior addition of oil to dry gluten does not hinder hydration. The reverse sequence is also workable; i.e., similar amounts of oil will also be absorbed and held by gluten which has first been hydrated with 2 parts of water.

Most food products contain intrinsic or added fat. The fat absorption property of vital gluten can help to prevent it from becoming free fat.

## ADHESIVE AGENT

The adhesive properties of vital gluten were demonstrated and measured in a relative way in the following test:

> Vital gluten was hydrated with 1½ parts water. This was spread in a thin layer between two pieces of ¾ in. fir plywood, 1¼ x 3 in. in size. They were tightly pressed together by hand. Some were dried at 130° C. for 20 hours, others at 50° C. for 6 days, and still others were air dried at room temperature (approx. 25° C.) for one week. In all cases, the boards could not be parted by hand.
>
> The bonded sets of plyboards were struck repeatedly with a hammer to impart a shearing force, until the boards parted. The gluten layer generally was intact, but either a film of the wood gave away, or one of the boards shattered across the grain, or there was failure of the bond between the layers of the plywood. Two samples are illustrated in Figure 1.

**Figure 1. Two test pieces showing the strength of a vital gluten paste dried between two pieces of plywood.**

These tests demonstrate that the bonding strength of the gluten exceeds the strength of the wood itself or of the commercial plywood adhesive. A similar means of reference is the observation that when gluten is oven dried on pyrex glass plates, there is a flaking and failure of the glass surface where the gluten is removed from the plates after being dried.

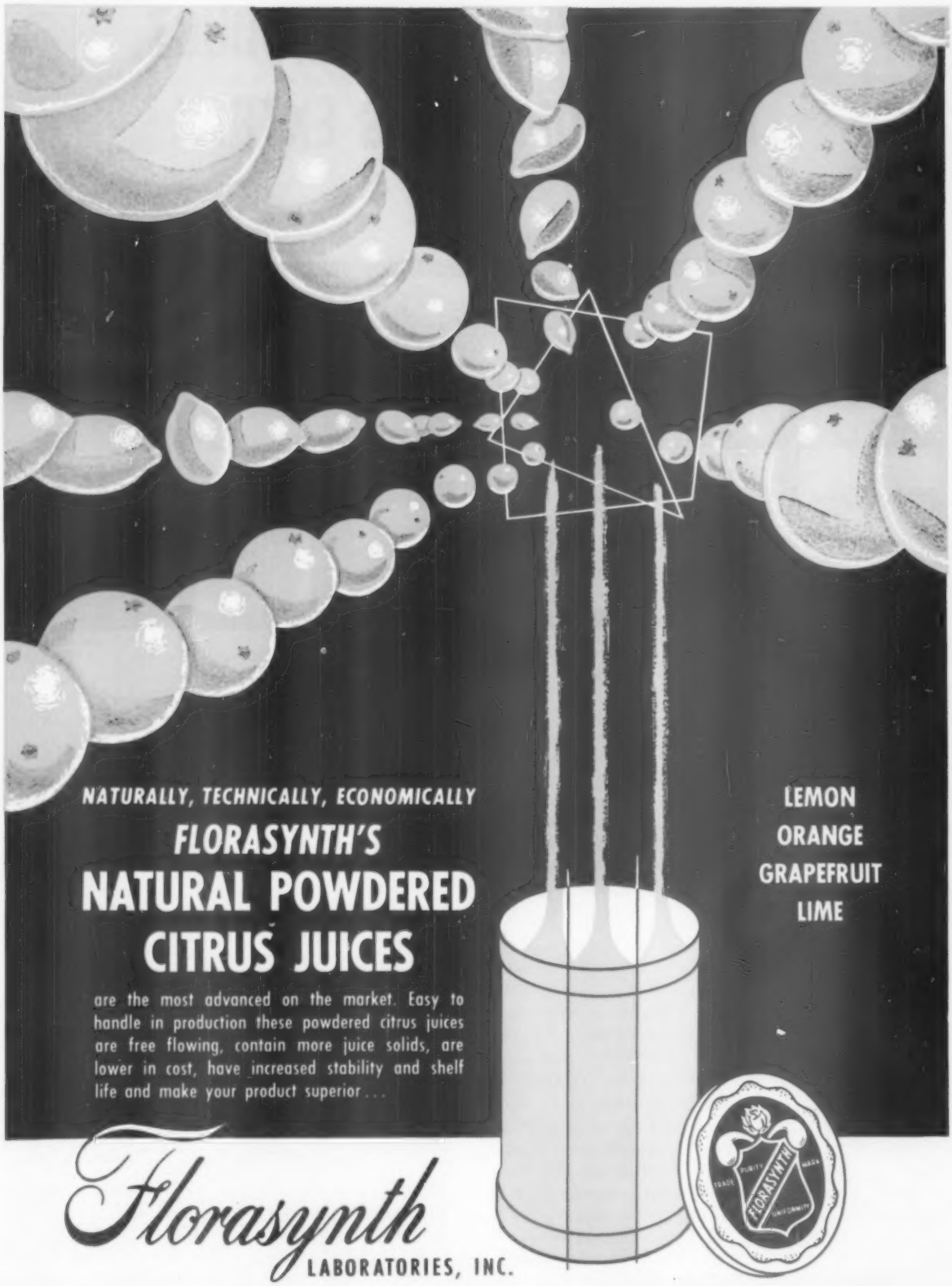
Food materials do not lend themselves to a graphic demonstration such as this. It is difficult to illustrate in a measurable manner the degree of adhesiveness which vital gluten will provide between the individual discrete particles in food formulation. However, the need for physical binding is proven by the weak, loose or crumbly food products which come to mind. Such an application would be as a binder in sausages, especially in those types where the carcass portions that are used have a low moisture absorption capacity.

## COHESIVE AGENT

The cohesive action may be considered a result of the dough and film-forming nature of the hydrated gluten. Thus, it may be stretched and kneaded into a multicelled elastic structure which surrounds and envelops other relatively inert ingredients and holds the mixture together as a single mass independent of the existence of adhesiveness between the gluten and the other ingredients. This is cohesiveness in a rigidly literal sense, meaning "to stick to itself."

This factor was tested by combining calcium carbonate (precipitated chalk, USP, powdered) with dry vital gluten which was hydrated for 2 hours and then checked for dough quality. Calcium carbonate was selected because it is inert, insoluble, and the particles are small and free from angularity which might cut or puncture the film. At the same time, because it is a fine powder, it presents a very large surface per unit of weight and therefore is more difficult to envelop.

The amount of water that can be added for good doughing characteristics is rather exact. These dough balls were checked after setting overnight and retained about the same doughing quality as initially set forth. In the proportion of 10 parts vital gluten to 50 parts calcium carbonate, there was no real dough-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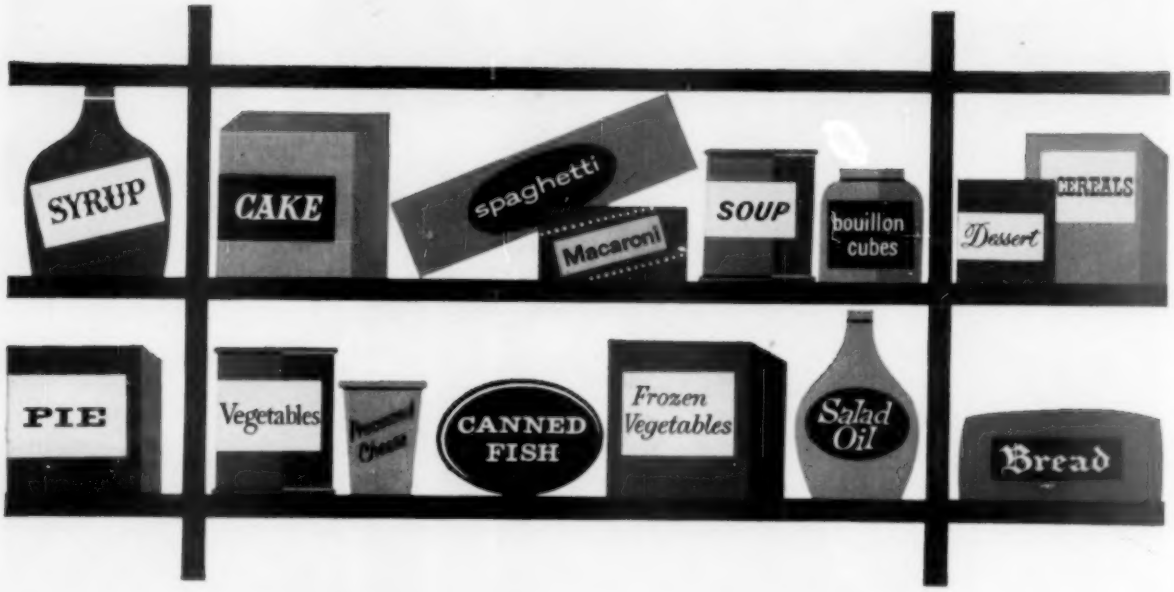


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TABLE 3

Capacity of vital gluten dough to envelop inert material

| Vital gluten | Calcium carbonate | Water | Dough quality |
|---|---|---|---|
| *grams* | *grams* | *ml.* | |
| 10 | 0 | 20 | Good |
| 10 | 5 | 20 | Good |
| 10 | 7.5 | 20 | Good |
| 10 | 10 | 20 | Medium |
| 10 | 20 | 25 | Poor |
| 10 | 50 | 45 | Very poor/none |
| 0 | 10 | 15 | None |

ing quality as such, but merely a stickiness of the paste.

Applications of this property tend to parallel the uses of both the adhesive property and the action as a dough former. Bran, nuts, or raisins in baked goods, which are held in place by being surrounded by the gluten in the formula, exemplify some of the applications.

## DOUGH FORMER

Forming a dough by mixing wheat flour with wa goes back to antiquity. By dictionary definitio., gluten is the tough, viscid, nitrogenous substance remaining when dough is washed to remove the starch. This dough-forming characteristic resides in the gluten—in the vital gluten—and disappears when the gluten is devitalized or denatured by heat.

Doughing characteristic of vital gluten may be measured by a farinograph with a simple sytem consisting of gluten, refined starch, and water. Elimination of flour solubles, salts and other agents removes the factors which confuse the measurement. In Figure 2A is shown the farinogram made by mixing 8 g. of vital gluten, 40 g. of wheat starch, and 32 ml. of water in the small farinograph bowl. This represents a sample of strong gluten with good elasticity. The effect of increasing proportions of devitalized gluten is shown in Figures 2B, 2C, and 2 D. The behavior is summarized in Table 4.

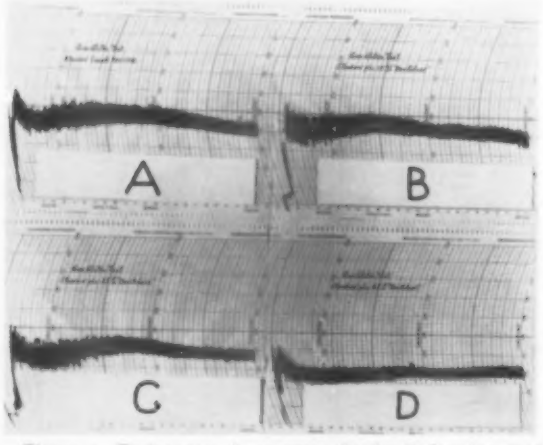


**Figure 2. Farinogram A measures the dough-forming characteristic of vital gluten in a dough with starch and water. In farinograms B, C, and D devitalized gluten is substituted progressively in the amounts of 15, 33, and 67%, with almost complete disappearance of the dough characteristic in D.**

TABLE 4

Dough characteristics of vital vs. devitalized gluten

| Fig. | Gluten composition | | Dough strength | Dough elasticity |
|---|---|---|---|---|
| | % Vital | % Denatured | | |
| 3A | 100 | 0 | Strong | Good |
| 3B | 85 | 15 | Fair | Poor |
| 3C | 67 | 33 | Very weak | Little |
| 3D | 33 | 67 | None | No cohesion |

This chart and the farinograms give a relative measure of the dough-forming characteristic of vital gluten. Uses of this characteristic are many. They are based on a number of uses of flour itself, but to an augmented and controllable degree.

The applications tend to overlap with some of the other functional properties. Because doughs are traditionally in the realm of the baker, mention should be made of the benefits in bakery products, which include improvements in grain, texture, volume, crumb, yield and softness. These improvements result from the use of added vital gluten wherever the flour or the formula fails to provide adequate protein properties.

## STRENGTHENING AGENT

An example of the strengthening property is given by Winston *(3)*. His studies on macaroni products showed that there was improved resistance to breakage in the extruded, dried products when the formula contained added vital gluten. The comparison was made between a reference sample of spaghetti at 10.8% protein and 2 samples raised to 12.0% and 12.7% protein by the addition of vital gluten. Breaking strength was increased 8.4% and 10.1%, respectively.

Similar results were obtained with pretzels, where breakage in the package is a troublesome problem *(2)*. This breakage is reduced by adding vital gluten to the extent of ¾% to 1½% basis flour weight. Overuse of vital gluten in pretzels results in their becoming too hard—further proof of the strengthening action. This excessive effect is easily demonstrated with 3% vital gluten in the formula.

The strength provided in both cases appears to be related to the ability of vital gluten to form what has been called rigid expanded structures. This will be recognized by anyone who has ever vacuum-dried freshly washed gluten. In Figure 3A a 50-g. portion of dry vital gluten is shown. In Figure 3B a 150-g. dough ball weighing 50 g. on the dry basis is depicted. Next, in Figure 3C is a similar amount after drying in a vacuum oven. Figure 3D shows a similarly dried portion, after partial crushing. The cellular structure helps to explain how rigidity is developed by the gluten in this example.

Cooking and denaturing will modify this structure, results depending on the sequence of processing steps in the preparation of the food. The examples in the photographs serve merely to illustrate the strength-giving property in its simplest form. As in the case of macaroni and pretzels, it is on the finished products that the meaningful measurement should be made.

It is only necessary to mention in passing the fact

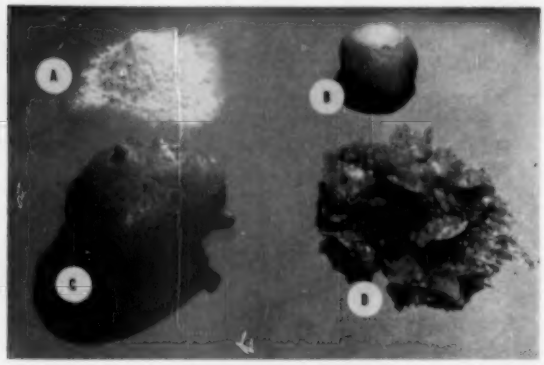


**Figure 3. Illustrating the rigidity factor in vital gluten.**
**A. 50 grams powdered dry vital gluten.**
**B. 50 grams hydrated into a dough with 100 grams of water.**
**C. Similar dough, dried in vacuum oven.**
**D. Dried portion after partial crushing to illustrate the cellular structure.**

known to all bakers that protein adds to the strength of a dough and to the structure of the bread made from it.

## SUMMARY

Vital gluten is now well recognized as a high protein food ingredient (up to 80% protein on the dry solids basis). This in itself is unusual. However, most of the present and potential uses depend on one or more of the functional properties of vital gluten. This paper has identified and described these properties or functions; namely, (1) protein fortifier, (2) hydration agent, (3) oil absorber, (4) adhesive agent, (5) cohesive agent, (6) dough former, and (7) strengthening agent.

As this list demonstrates, vital gluten is a highly useful food ingredient. It is produced under controlled conditions from selected flour to meet rigid product specifications. It has the great advantage of being bland in both flavor and odor and thus may be incorporated in a wide variety of food products. The physical form is a "flour" or fine powder which is readily handled, stored or shipped in the standard 100-pound bags. Being a powder, it may be combined with dry or wet ingredients in the users' formulations. Knowledge of these functions and properties should be helpful to the food technologists and to food manufacturers who have the responsibility of developing and producing the most saleable and palatable as well as the most nutritious products possible.

## Acknowledgment

The authors especially thank Haven D. Kaslow and Lloyd Baggenstoss, both of General Mills, Inc., for the farinograph studies and laboratory assistance respectively.

## LITERATURE CITED

1. Dubois, D. K., and Cotton, R. H. Vital wheat gluten, a new aid for the bakers. *Bakers Digest*, 31, 56 and ff. (1957).
2. Survey, January, 1957. National Pretzel Bakers Institute.
3. Winston, James J. Better macaroni products with gum gluten. *Food Eng.*, 27, 73 (1955).

# Notes and Letters

## Some Effects of Ionizing Radiations on Gelatin*

EARLY INVESTIGATORS *(2, 5, 6)* reported that irradiation with x-rays reduced the viscosity of dilute aqueous gelatin solutions. More recently it has been possible to use much higher doses, and Hannan *(1)* reports that gelatin gels exposed to doses of about one million rep become irreversible and undergo syneresis.

We have investigated the effect of ionizing radiations on the intrinsic viscosity and gel strength of gelatin irradiated in the dry state. Two sources of radiation were used: a Cobalt$^{60}$ source (gamma emitter) for doses of two million rep or less, and a General Electric Resonant Transformer (electron accelerator) for doses of greater magnitude. The viscosity measurements were made on gelatin dissolved in 0.15 M sodium chloride solution using an Ostwald-Fenske (Cannon) viscometer at 55° C. The intrinsic viscosity was found by extrapolating to zero concentration a plot of the natural log. of relative viscosity/concentration versus concentration. The gel strength measurements were made on a Bloom gelometer according to the official method of the A.O.A.C. *(3)*.

The results of the intrinsic viscosity determinations presented in Figure 1 indicate that at the doses employed, radiation-induced cross-linking of polymer chains is relatively small compared to the degree of fracturing of peptide links within individual molecules.

The gel strength measurements presented in Table 1 indicate that the degree of splitting of the gelatin molecules was insufficient to cause any reduction in the gel strength. Apparently the doses were not large enough to reduce the molecular weight of the gelatin to the critical point at which the gel strength starts to decrease *(4)*.

TABIE 1

**Effect of Cobalt-60 gamma rays on bloom-gel strength**

| Dose | Gel strength |
|---|---|
| Control | 280 |
| 50,000 rep | 282 |
| 100,000 rep | 280 |
| 250,000 rep | 279 |
| 500,000 rep | 284 |
| 1,000,000 rep | 283 |
| 2,000,000 rep | 282 |

RICHARD I. MATELES
SAMUEL A. GOLDBLITH
Department of Food Technology
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

2 July 1958

* Contribution No. 345 from the Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

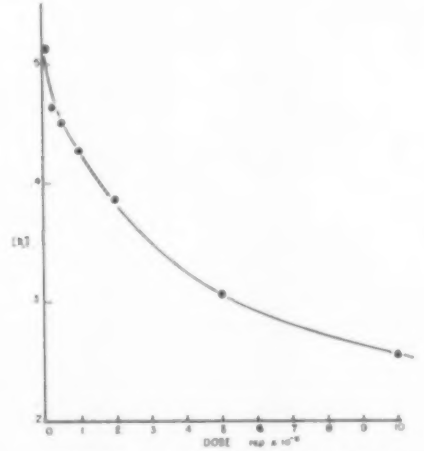


**Figure 1. Plot of intrinsic viscosity of gelatin versus dose received.**

LITERATURE CITED

1. HANNAN, R. S. *Food Preservation*. 1956. Chemical Publishing Company, New York, N. Y. pp. 76–77.
2. KHENOKH, M. A. The effect of the penetrating radium rays on the colloid-chemical properties of gelatin sols (in Russian), *Zhurnal Obshchei Khimii*, 11, 776 (1941). [From *CA* 36, 2473 (1942)].
3. *Methods of Analysis*. Association of Official Agricultural Chemists, 8th Edition. 1955. A.O.A.C., Washington, D. C., p. 364.
4. WARD, A. G. The chemical structure and physical properties of gelatin. *J. Photographic Sci.*, 3, 60 (1955).
5. WOODWARD, H. Q. The effect of X-radiation on the viscosity of gelatine. *J. Phys. Chem.*, 36, 2543 (1932).
6. ZHUKOV, I. I., AND UNKOVSKAYA, V. A. Influence of radon on the viscosity of gelatin solutions. (in Russian) *Zhurnal Fizicheskoi Khimii*, 62, 581 (1930). [From *CA* 24, 4708 (1930)].

# Locating Russian Materials on Food and Food Technology

NOT MUCH IS KNOWN in the United States about progress in Russia in the food and food technology fields. That there is considerable activity in the various food areas is, however, evident from the output of research, technical and specialized literature. The difficulties of the language and the scarcity in American libraries of Russian food publications are doubtless the chief reasons for our slight grasp of Russian contributions. It may come as a surprise to food technologists that the subject index of the Library of Congress *Serial Publications of the Soviet Union, 1939–1957 (2)* lists at least 96 different titles that clearly reflect specialized food interests. Yet the list shows that only 38, or roughly one third, are held even in part in American libraries. These holdings would make even less of a showing if only fairly complete sets were counted. Since this total of 96 does not include the journals which could be considered at least partly in the food field, and none of those in agriculture, chemistry, chemical engineering and medicine, all of which print some articles of interest to the food scientist and technologist, it is not a complete picture but it does show that specialized materials which could be of real importance are not generally available.

## DISTRIBUTION IS LIMITED

The distribution of the 38 titles indicates another difficulty. The Library of Congress has at least 32 of them, while 22 are found in the Library of the U. S. Department of Agriculture. Other libraries having materials are largely on the Atlantic seaboard, although a few are in California. Only two titles (one on canning in a college library, and one on tea in a university library) are recorded for the Middle West; none are listed in libraries in the South. Nine titles are held by the New York Public Library, and three are at the Columbia University Library. Harvard, which has one of the outstanding collections of Russian materials, has three titles; while Yale with another good collection has none. Cornell University reports three titles out of the list. On the Pacific Coast the University of California at Berkeley holds eight titles, the Hoover Library at Leland Stanford University three, and two are found at the University of California at Los Angeles.

## CLASSIFICATION DIFFICULTIES

An indication that the materials held in the United States tend to the basic background, rather than to the applied aspects, is also found in the subject headings assigned to the various titles. It should be remembered that subject headings given for titles not in the United States were assigned from the titles of the serials and not from actual inspection of the contents. Of the four titles given under the broad heading of "Food" all are held in the United States, one by five different libraries. Of the 19 titles listed under "Food Industry and Trade" only three are held in the United States, the Library of Congress having all three and the U. S. D. A. Library two. This leaves 16 titles not held that seem to be on the food trade in general. One title which was classified as "Food Research" was held by two libraries, one being the Library of Congress and the other Cornell University. Of three titles under "Nutrition" two are held in the United States, one title by 8 different libraries. Only two of the 10 titles recorded as dealing with meat are held in American libraries, but one of these is held by 8 different libraries. Of the five titles listed under "Sugar, Manufacturing and Refining," four are held in the United States, one by 9 different libraries. The 8 entries under "Beets and Beet Sugar" were not analyzed because it was not possible to tell which related to the agricultural and which to the food industry aspects.

Russian journals covering the pure sciences are more widely distributed in the United States, and certain of them are translated regularly under the sponsorship of some of the learned societies, with funds in part supplied by governmental sources. Although many of the articles so translated are basic to the work of the food technologist they do not include the more specialized reports which could be of even greater interest.

There has been, of course, an effort on the part of the Library of Congress and the U. S. D. A. Library to select for their collections the most important journals in the fields covered. This could lead to a supposition that the third of the total production relating to food held by these two libraries represents the most important contributions, but since the other titles are not available it is not possible to check on this assumption. In any event those journals which are held have a possibility of use through published indexes.

Mention should be made at this point of a new, additional source for obtaining information on the names and specific coverage of Russian journals in food science and technology. The *Bibliography of Food*, compiled by two British authors, E. Alan Baker and D. J. Foskett, and published in the U.S.A. by the Academic Press Inc., New York, contains a selected list of bibliographies, journals, and organizations devoted to food investigations. Russia and the satellite countries appear to be well represented. The book is just off the press at the time of this writing and has not been examined studiously.

## TOOLS FOR LOCATING RUSSIAN MATERIALS

Tools for locating materials in the Russian language serials, at least those held in the United States, are fairly numerous. The Library of Congress issues the *Monthly Index of Russian Acquisitions (5)* which not only lists the titles of all articles in the journals received, but also includes entries for books and monographs, even including some for items that are not

held by American libraries. This monthly index is quite complete and detailed, particularly from the subject point of view, but it is not cumulated so that it is necessary to check each monthly issue as a separate when making a literature search.

Because of the number of Russian titles held by the Library of the U. S. Department of Agriculture the *Bibliography of Agriculture (4)* regularly contains references to many articles, as well as to books and separates, of interest to workers in the food field. In addition the list of translations, which appears in each issue, includes a record of any translations from Russian in the food field.

Translations of Russian articles and books were formerly listed in the *Bibliography of Translations of Russian Scientific and Technical Publications (6)* issued by the Library of Congress. This publication was, however, discontinued at the end of 1956 and combined with the *Translation Monthly (3)* published by a Committee of the Special Libraries Association at the John Crerar Library in Chicago. The number of translations in the food and food technology fields, as might be expected from the limited number of Russian journals held in the United States, has not been great but many of those listed are held by the translation center and are available for loan or copying.

Various abstract services pay considerable attention to Russian materials. Both *Chemical Abstracts* and *Biological Abstracts* should be consulted for materials of interest because they index the Russian journals in the pure sciences which have basic articles, even though their coverage of the specialized journals is not extensive. *Chemical Abstracts* issued in 1956 a *List of Periodicals Abstracted by Chemical Abstracts (1)* which also notes which libraries receive the titles. This list is not, however, as complete a record of holdings as the one issued by the Library of Congress.

## FOOD ABSTRACTS NOT A SPECIALIZED SERVICE IN RUSSIA

Much has been reported in the press about the activities of the All-Union Institute of Scientific and Technical Information (Institut nauchnoi informatskii of Akadademii nauk SSSR) which publishes twelve abstract journals with a common title of *Referathivnyi Zhurnal*. Those for chemistry and biochemistry would probably cover certain of the basic sciences for the food technologist but there does not seem to be any abstract service which would include the specialized subjects of food and food technology. While these services have been operating for only a few years there seems to be a number of subscriptions in the United States with the Khimiya section being recorded for 13 libraries for the maximum of those which might have a relationship to the food fields.

### LITERATURE CITED

1. *Chemical Abstracts.* List of periodicals abstracted by Chemical Abstractts with key to library files and other information. Columbus, O., Chemical Abstract Service, 1956. 314 p. Issued separately as a part of Chemical Abstracts, v. 50, no. 53, Dec. 10, 1956.
2. Smits, Rudolf, comp. *Serial publications of the Soviet Union, 1939–1957: a bibliographical check list.* Washington, Cyrillic Bibliographic Project, Processing Department, Library of Congress, 1958. 459 p. Sold by the U. S. Superintendent of Documents, Govt. Print. Off.
3. *Translations monthly,* v. 1, 1955-date. Chicago, Special Libraries Association, John Crerar Library, 1955-date. Preceded by SLA List of Translations, Oct. 1, 1953. 72 p., and Supplement, Sept. 1, 1954. 62 p.
4. U. S. Department of Agriculture. Library. *Bibliography of agriculture,* v. 1, 1942-date. Washington, 1942-date.
5. U. S. Library of Congress. Processing department. *Monthly index of Russian accessions.* v. 1, 1948-date. Washington, U. S. Govt. Print. Off., 1948-date. Previously issued as *Monthly list of Russian accessions.*
6. U. S. Library of Congress. Scientific Translations Center. *Bibliography of translations from Russian scientific and technical literature.* Lists 1-39, Oct. 1953-Dec. 1956 Washington, 1953-1956.

James G. Hodgson
Librarian
QM Food and Container Institute for the Armed Forces, Research and Engineering Command, U. S. Army

Chicago, 25 August 1958

# Annual Meeting Papers

The Editor
FOOD TECHNOLOGY

Dear Sir:

I have had the opportunity to attend a number of the annual meetings of the IFT, and have derived very substantial benefits from them. There are a few suggestions which I wish to mention, for whatever they are worth. These remarks are not meant as criticism but are offered constructively. These views are shared, I might add, by several individuals who discussed them with me at Chicago.

There is an increasing trend for papers to become less interesting. This is apparently due to several factors. First, many of the speakers read *all* of the details of the paper, including minute details of equipment and technique. There probably are very few people present who are interested in and can absorb all of those details. I have found that the most informative speaker is the one who speaks, without reading, touching on the highlights, as one might do in presenting an elaborated summary and conclusions. It is good to have a manuscript handy to answer details if questioned, but details of procedure can be obtained when the paper is published.

Then, there is a tendency to present research which encompasses only a very narrow phase of a topic. Too minute to be of any general interest, such papers seem rather inappropriate for a national meeting.

When papers are credited to several authors jointly, and especially when one or more prominent persons are concerned, the paper is usually presented by a younger member of the team, who usually reads everything *verbatim*. I have noticed that when one of the more experienced members presents such a paper, he generally does *not* read it, but makes an authoritative, interesting talk out of it, and is readily able to supply requested details when questioned. The practice of permitting the junior member to read the paper is, naturally, of considerable value to the individual reader, but often it detracts from the interest to the general audience. When a junior member presents a paper, I believe he should be well coached before being permitted to address the audience. This should be a part of his training.

I think that the use of slides should be given some consideration. Often the speaker reads much of the projected data himself instead of pointing out the highlights. This detailed reading, which the audience can read anyway, often deadens interest. When reading these data in detail, the speaker often addresses the screen, turns away from the microphone, and loses the attention of the audience. Furthermore, I suggest a little advance planning in the use of slides, to avoid prolonged darkening of the room.

Here is a summary of some of the factors that have come to mind:

1. Speakers should avoid verbatim reading of detailed manuscripts; should speak in more general terms, without reading, and should discuss highlights.

2. Avoid presenting many papers that are narrow in scope; the so-called research problem may actually be a seminar concern rather than a national meeting topic.

3. Avoid too frequent use of junior members of a team presenting the paper. Give the audience a break by letting the "big guns" talk. Note that this suggestion includes the phrase "too frequent." The junior members are very important and by no means should be by-passed.

4. Reduce tendency of speaker reading all data of each slide; the audience can do the reading itself. With few exceptions, confine remarks to interpreting the data projected.

5. Encourage speaker to face audience when discussing slides.

6. Organize slide projection to keep the room darkened for the minimum practicable time.

I sincerely hope that these remarks will not be taken as criticism of the management of the meetings. I have much respect for them. I simply offer them as suggestions for improvement. No doubt the place to begin educational work in improving the presentation of annual meeting papers—and their style and content, is the organization that sponsors the paper. The excellent work being done in food research and development should not be clouded by inadequate presentations.

Very truly yours
*A. E. Frey*
Chief Chemist
Horn & Hardart
600 West Fiftieth Street
New York 19, N. Y.

20 June 1958

# Food Additives Amendment Enacted

**John F. Mahoney, Chm.**
Committee on Food Additives, IFT

On September 6, 1958, President Eisenhower signed into law the Food Additives Amendment of 1958 culminating a ten-year effort to improve federal regulatory control over the use of food additives. Because of its importance to members of the Institute, the full text of the law is reproduced here.

The new amendment covers all food additives not generally recognized as safe except for pesticides and pesticide residues which are dealt with under the Pesticide Chemicals Amendment of 1954. Substances previously sanctioned under the Food, Drug and Cosmetic Act, Meat Inspection Act, and Poultry Products Inspection Act are also exempt.

Significant features of the new amendment include the requirement that complete information be submitted and approval obtained from FDA prior to commercial use of a new food additive, provision for the issuance of tolerance limitations, if necessary, to assure that the additive will be safe, and provision for prohibiting the use of any food additive where evidence is inadequate to assure safety. In considering whether an additive is safe, its probable use, cumulative effect, and margin of safety will be considered, except that no additive inducing cancer when ingested shall be deemed safe.

It is expected that the Food and Drug Administration will soon issue initial regulations dealing with additives exempted from control and procedures for filing petitions for tolerances.

The amendment follows:

**Public Law 85-929**
**85th Congress, H. R. 13254**
**September 6, 1958**

**AN ACT**[a]

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That this Act may be cited as the "Food Additives Amendment of 1958."[b]

SEC. 2. Section 201, as amended, of the Federal Food, Drug, and Cosmetic Act is further amended by adding at the end of such section the following new paragraphs:[c]

"(s) The term 'food additive' means any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; and including any source of radiation intended for any such use), if such substance is not generally recognized, among experts qualified by scientific training and experience to evaluate its safety, as having been adequately shown through scientific procedures (or, in the case of a substance used in food prior to January 1, 1958, through either scientific procedures or experience based on common use in food) to be safe under the conditions of its intended use; except that such term does not include—

"(1) a pesticide chemical in or on a raw agricultural commodity; or

"(2) a pesticide chemical to the extent that it is intended for use or is used in the production, storage, or transportation of any raw agricultural commodity; or

"(3) any substance used in accordance with a sanction or approval granted prior to the enactment of this paragraph pursuant to this Act, the Poultry Products Inspection Act (21 U. S. C. 451 and the following) or the Meat Inspection Act of March 4, 1907 (34 Stat. 1260), as amended and extended (21 U. S.C. 71 and following).[d]

"(t) The term 'safe', as used in paragraph (s) of this section and in section 409, has reference to the health of man or animal."

SEC. 3. (a) Clause (2) of section 402 (a), as amended, of such Act is amended to read as follows:

"(2) (A) if it bears or contains any added poisonous or added deleterious substance (except a pesticide chemical in or on a raw agricultural commodity and except a food additive) which is unsafe within the meaning of section 406, or (B) if it is a raw agricultural commodity and it bears or contains a pesticide chemical which is unsafe within the meaning of section 408 (a), or (C) if it is, or it bears or contains, any food additive which is unsafe within the meaning of section 409: *Provided*, That where a pesticide chemical has been used in or on a raw agricultural commodity in conformity with an exemption granted or a tolerance prescribed under section 408 and such raw agricultural commodity has been subjected to processing such as canning, cooking, freezing, dehydrating, or milling, the residue of such pesticide chemical remaining in or on such processed food shall, notwithstanding the provisions of sections 406 and 409, not be deemed unsafe if such residue in or on the raw agricultural commodity has been removed to the extent possible in good manufacturing practice and the concentration of such residue in the processed food when ready to eat is not greater than the tolerance prescribed for the raw agricultural commodity;".[e]

(b) Section 402 (a), as amended, of such Act is further amended by striking out the period at the end

[a] 72 Stat. 1784.
To protect the public health by amending the Federal Food, Drug, and Cosmetic Act to prohibit the use in food of additives which have not been adequately tested to establish their safety.

[b] Food Additives Amendment of 1958.

[c] 52 Stat. 1041. 21 USC 321. Definitions.

[d] 71 Stat. 441.

[e] Insanitary ingredients. 21 USC 342.

thereof and inserting in lieu thereof a semicolon and the following: "or (7) if it has been intentionally subjected to radiation, unless the use of the radiation was in conformity with a regulation or exemption in effect pursuant to section 409."[f]

(e) The first sentence of section 406 (a) of such Act is amended by striking out "clause (2)" wherever it appears in such sentence and inserting in lieu thereof "clause (2) (A)".[g]

SEC. 4. Chapter IV of such Act is amended by adding at the end thereof the following new section:[h]

"FOOD ADDITIVES

"Unsafe Food Additives

"SEC. 409. (a). A food additive shall, with respect to any particular use or intended use of such additives, be deemed to be unsafe for the purposes of the application of clause (2) (C) of section 402 (a), unless—

"(1) it and its use or intended use conform to the terms of an exemption which is in effect pursuant to subsection (i) of this section; or

"(2) there is in effect, and it and its use or intended use are in conformity with, a regulation issued under this section prescribing the conditions under which such additive may be safely used.

While such a regulation relating to a food additive is in effect, a food shall not, by reason of bearing or containing such an additive in accordance with the regulation, be considered adulterated within the meaning of clause (1) of section 402 (a).

"Petition To Establish Safety

"(b) (1) Any person may, with respect to any intended use of a food additive, file with the Secretary a petition proposing the issuance of a regulation prescribing the conditions under which such additive may be safely used.

"(2) Such petition shall, in addition to any explanatory or supporting data, contain—

"(A) the name and all pertinent information concerning such food additive, including, where available, its chemical identity and composition;

"(B) a statement of the conditions of the proposed use of such additive, including all directions, recommendations, and suggestions proposed for the use of such additive, and including specimens of its proposed labeling;

"(C) all relevant data bearing on the physical or other technical effect such additive is intended to produce, and the quantity of such additive required to produce such an effect;

"(D) a description of practicable methods for determining the quantity of such additive in or on food, and any substance formed in or on food, because of its use; and

"(E) full reports of investigations made with respect to the safety of such additive, including such information as to the methods and controls used in conducting such investigations.

"(3) Upon request of the Secretary, the petitioner shall furnish (or, if the petitioner is not the manufacturer of such additive, the petitioner shall have the manufacturer of such additive furnish, without disclosure to the petitioner) a full description of the methods used in, and the facilities and controls used for, the production of such additive.

"(4) Upon request of the Secretary, the petitioner shall furnish samples of the food additive involved, or articles used as components thereof, and of the food in or on which the additive is proposed to be used.

"(5) Notice of the regulation proposed by the petitioner shall be published in general terms by the Secretary within thirty days after filing.

"Action on the Petition

"(c) (1) The Secretary shall—

"(A) by order establish a regulation (whether or not in accord with that proposed by the petitioner) prescribing, with respect to one or more proposed uses of the food additive involved, the conditions under which such additive may be safely used (including, but not limited to, specifications as to the particular food or classes of food in or in which such additive may be used, the maximum quantity which may be used or permitted to remain in or on such food, the manner in which such additive may be added to or used in or on such food, and any directions or other labeling or packaging requirements for such additives deemed necessary by him to assure the safety of such use), and shall notify the petitioner of such order and the reasons for such action; or

"(B) by order deny the petition, and shall notify the petitioner of such order and of the reasons for such action.

"(2) The order required by paragraph (1) (A) or (B) of this subsection shall be issued within ninety days after the date of filing of the petition, except that the Secretary may (prior to such ninetieth day), by written notice to the petitioner, extend such ninety-day period to such time (not more than one hundred and eighty days after the date of filing of the petition) as the Secretary deems necessary to enable him to study and investigate the petition.

"(3) No such regulation shall issue if a fair evaluation of the data before the Secretary—

"(A) fails to establish that the proposed use of the food additive, under the conditions of use to be specified in the regulation, will be safe: *Provided*, That no additive shall be deemed to be safe if it is found to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal; or

"(B) shows that the proposed use of the additive would promote deception of the consumer in violation of this Act or would otherwise result in adul-

[f] 21 USC 342.
[g] 21 USC 346.
[h] 21 USC 341 *et seq.*

teration or in misbranding of food within the meaning of this Act.

"(4) If, in the judgment of the Secretary, based upon a fair evaluation of the data before him, a tolerance limitation is required in order to assure that the proposed use of an additive will be safe, the Secretary—

"(A) shall not fix such tolerance limitation at a level higher than he finds to be reasonably required to accomplish the physical or other technical effect for which such additive is intended; and

"(B) shall not establish a regulation for such proposed use if he finds upon a fair evaluation of the data before him that such data do not establish that such use would accomplish the intended physical or other technical effect.

"(5) In determining, for the purposes of this section, whether a proposed use of a food additive is safe, the Secretary shall consider among other relevant factors—

"(A) the probable consumption of the additive and of any substance formed in or on food because of the use of the additive;

"(B) the cumulative effect of such additive in the diet of man or animals, taking into account any chemically or pharmacologically related substance or substances in such diet; and

"(C) safety factors which in the opinion of experts qualified by scientific training and experience to evaluate the safety of food additives are generally recognized as appropriate for the use of animal experimentation data.

"Regulation Issued on Secretary's Initiative

"(d) The Secretary may at any time, upon his own initiative, propose the issuance of a regulation prescribing, with respect to any particular use of a food additive, the conditions under which such additive may be safely used, and the reasons therefor. After the thirtieth day following publication of such a proposal, the Secretary may by order establish a regulation based upon the proposal.

"Publication and Effective Date of Orders

"(e) Any order, including any regulation established by such order, issued under subsection (c) or (d) of this section, shall be published and shall be effective upon publication, but the Secretary may stay such effectiveness if, after issuance of such order, a hearing is sought with respect to such order pursuant to subsection (f).

"Objections and Public Hearing

"(f) (1) Within thirty days after publication of an order made pursuant to subsection (c) or (d) of this section, any person adversely affected by such an order may file objections thereto with the Secretary, specifying with particularity the provisions of the order deemed objectionable, stating reasonable grounds thereof, and requesting a public hearing upon such objections. The Secretary shall, after due notice, as promptly as possible hold such public hearing for the purpose of receiving evidence relevant and material to the issues raised by such objections. As soon as practicable after completion of the hearing, the Secretary shall by order act upon such objections and make such order public.

"(2) Such order shall be based upon a fair evaluation of the entire record at such hearing, and shall include a statement setting forth in detail the findings and conclusions upon which the order is based.

"(3) The Secretary shall specify in the order the date on which it shall take effect, except that it shall not be made to take effect prior to the ninetieth day after its publication, unless the Secretary finds that emergency conditions exist necessitating an earlier effective date, in which event the Secretary shall specify in the order his findings as to such conditions.

"Judicial Review

"(g) (1) In a case of actual controversy as to the validity of any order issued under subsection (f), including any order thereunder with respect to amendment or repeal of a regulation issued under this section, any person who will be adversely affected by such order may obtain judicial review by filing in the United States Court of Appeals for the circuit wherein such person resides or has his principal place of business, or in the United States Court of Appeals for the District of Columbia Circuit, within sixty days after the entry of such order, a petition praying that the order be set aside in whole or in part.

"(2) A copy of such petition shall be forthwith served upon the Secretary, or upon any officer designated by him for that purpose, and thereupon the Secretary shall certify and file in the court a transcript of the proceedings and the record on which he based his order. Upon such filing, the court shall have exclusive jurisdiction to affirm or set aside the order complained of in whole or in part. The findings of the Secretary with respect to questions of fact shall be sustained if based upon a fair evaluation of the entire record at such hearing. The court shall advance on the docket and expedite the disposition of all causes filed therein pursuant to this section.

"(3) The court, on such judicial review, shall not sustain the order of the Secretary if he failed to comply with any requirement imposed on him by subsection (f) (2) of this section.

"(4) If application is made to the court for leave to adduce additional evidence, the court may order such additional evidence to be taken before the Secretary and to be adduced upon the hearing in such manner and upon such terms and conditions as to the court may seem proper, if such evidence is material and there were reasonable grounds for failure to adduce such evidence in the proceedings below. The Secretary may modify his findings as to the facts and order by reason of the additional evidence so taken, and shall file with the court such modified findings and order.

"(5) The judgment of the court affirming or setting aside, in whole or in part, any order under this section shall be final, subject to review by the Supreme Court of the United States upon certiorari or certification as provided in section 1254 of title 28 of the United States Code. The commencement of proceedings under this section shall not, unless specifically ordered by the court to the contrary, operate as a stay of an order.

"Amendment or Repeal of Regulations

"(h) The Secretary shall by regulation prescribe the procedure by which regulations under the foregoing provisions of this section may be amended or repealed, and such procedure shall conform to the procedure provided in this section for the promulgation of such regulations.

"Exemptions for Investigational Use

"(i) Without regard to subsections (b) to (h), inclusive, of this section, the Secretary shall by regulation provide for exempting from the requirements of this section any food additive, and any food bearing or containing such additive, intended solely for investigational use by qualified experts when in his opinion such exemption is consistent with the public health."

SEC. 5. Section 301 (j) of such Act is amended by inserting "409," after "404,".[i]

SEC. 6. (a) Except as provided in subsections (b) and (c) of this section, this Act shall take effect on the date of its enactment.[j]

(b) Except as provided in subsection (c) of this section, section 3 of this Act shall take effect on the one hundred and eightieth day after the date of enactment of this Act.[k]

(c) With respect to any particular commercial use of a food additive, if such use was made of such additive before January 1, 1958, section 3 of this Act shall take effect—[l]

(1) either (A) one year after the effective date established in subsection (b) of this section, or (B) at the end of such additional period (but not later than two years from such effective date established in subsection (b) as the Secretary of Health, Education, and Welfare may prescribe on the basis of a finding that such extension involves no undue risk to the public health and that conditions exist which necessitate the prescribing of such an additional period, or

(2) on the date on which an order with respect to such use under section 409 of the Federal Food, Drug, and Cosmetic Act becomes effective,

whichever date first occurs.[m]

SEC. 7. Nothing in this Act shall be construed to exempt any meat or meat food product or any person from any requirement imposed by or pursuant to the Poultry Products Inspection Act (21 U. S. C. 451 and the following) or the Meat Inspection Act of March 4, 1907, 34 Stat. 1260, as amended and extended (21 U. S. C. 71 and the following).[n]

SEC. 8. The annual rate of basic compensation of the Commissioner of Food and Drugs shall be $20,000.[o]

SEC. 9. Section 208 (g) of the Public Health Service Act, as amended (42 U. S. C. 210 (g)), is amended by striking out the phrase "in the professional and scientific service" and inserting in lieu thereof the phrase "in the professional, scientific, and executive service" and by striking out the phrase "of specially qualified scientific or professional personnel" and inserting in lieu thereof "of specially qualified scientific, professional, and administrative personnel".[p]

Approved September 6, 1958.

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[i] 21 USC 331.
[j] Effective dates.
[k] *Ante*, p. 1784.
[l] *Ante*, p. 1784.
[m] *Ante*, p. 1785.
[n] 71 Stat. 441.
[o] Compensation of Commissioner.
[p] 69 Stat. 407, 70 Stat. 430, 741.

merous extremely interesting papers but space prohibits further discussion of these.

**New officers**

At the annual business meeting of the Association, Dr. J. H. Bruckner of Cornell University was elected President; G. E. Bearse of Western Washington Experiment Station First Vice President; and Dr. T. S. Bierly of the USDA Second Vice President. C. B. Ryan of Texas A & M was re-elected as Secretary-Treasurer. Meeting places for the next 3 years were announced as 1959, Iowa State; 1960, University of California at Davis; and 1961, Pennsylvania State University.

# IFT News

## Awards

### Call for Nominations

### Food Technology Industrial Achievement Award

The Institute of Food Technologists announces the establishment of a *Food Technology Industrial Achievement Award*. The Award will include the following:

To the Company or Institution concerned, a Bronze Plaque suitable for mounting.

To the individual(s) judged to have made major contributions to the achievement, either through basic research or development, public recognition at the time of presentation, and an engrossed plaque.

The purpose of this award is to honor an outstanding food process and/or product which represents a significant advance in the application of Food Technology to food production. It must be one which has been successfully applied in actual commercial operation for not less than 6 months or more than 4 years prior to September 15, 1958.

Any member of the Institute of Food Technologists may make nominations for the award. Each nomination must be in letter form and include the following:

a. Name of Company or Institution.

b. Name of Product and/or Process.

c. Description of Product or Process.

d. Statement of reason for considering this a meritorious achievement.

e. Statement listing individuals chiefly responsible for the achievement and their individual contributions.

f. Statement indicating the time and extent of commercial utilization.

Nominations must not exceed three, single-spaced, typewritten pages. Nominations should be sent to:

Institute of Food Technologists
176 West Adams Street
Chicago 3, Illinois

To be considered nominations must be postmarked not later than December 10, 1958.

## REGIONAL NEWS

### DIXIE

The Dixie Section of IFT held its combined summer meeting and annual social outing at the Carling Brewing Company, Atlanta, Georgia on August 22, 1958.

Arrangements for the meeting were made possible through the cooperation of General A. R. Bolling, Regional Vice President (former Third Army Commander) and Mr. Charles S. Cherry, Personnel Manager of the Carling Company.

The group had a tour of the most modern brewing plant in the South. Following the tour Mr. Bob Kunis, Chief Chemist, discussed the problems of quality control, sanitation, etc. in the brewing industry. Carling products, Black Label Beer, Red Cap Ale and Stag Beer, are sold throughout the 48 states.

Refreshments were served in the Carling Room and dinner in an adjacent room. Beer was on the house.

—*Cordelia Ellis*

### NORTHEAST

On Saturday, October 4, 1958, the season's activities began with our annual meeting at the University of Massachusetts in Amherst, Mass. The Food Technology Department at UMass. were the hosts. The new Student Union as well as the other $19 million worth of construction currently underway on the campus was shown to those interested.

A buffet luncheon (even better than last year's) was served by the combined Stewards Club and Food Management students at about 1:00 p.m.

Dr. William F. Hampton, Director of Research, National Cranberry Association, was our first speaker for the 1958-59 season. Dr. Hampton has been interested in food problems practically all his life and while with F.A.O. traveled about the World investigating general food problems in many countries. He gave us many interesting sidelights on the problems of world feeding.

## CHICAGO

The Chicago Section met jointly with the Food Tech Club of the Department of Food Technology, University of Illinois, Urbana, on Saturday, Septem-27. The day was perfect. The tours through the laboratories were excellently handled and most instructive. The famous Food Tech Club barbecued pork chops received rave notices from the 200 people lucky enough to participate in the luncheon. Just as billed, there were two serving lines and *no* speeches. With everything moving along at so high a level, the crowning feature of the day should have been a victory for the Illini. But they missed by a few points—which is the way the ball sometimes bounces. Wending their way back to Chicago after this pleasant and stimulating Autumn holiday, the Chicago Section members could truly feel that this was one of the finest of a long succession of joint meetings with our neighbor Sections. Congratulations to the Food Tech Club and Reid Milner for a full day of food, fun, and football. Equally pleasurable was the visit to the laboratories.

## SOUTHERN CALIFORNIA

SCIFTS opened the fall meetings, after the summer recess, on the regular third Wednesday of the month. The September meeting is traditionally the month in which the section's choice for FOOD MAN OF THE YEAR is featured. The 1958 nomination was Dr. Henry Borsook for his work in developing the multipurpose food under the sponsorship of Food for Millions Foundation. Mr. Edmund Clinton accepted the award for Dr. Borsook who was out of the country at that time, and gave the address of the evening. Mr. Clinton again explained the purpose of the MPF and stated that one packet, costing about 3 cents, supplied as much food value as ¼ pound steak, 1 cup milk, and 1 serving of peas. The Foundation is supported by gifts and the food is shipped to all parts of the world for distribution to the hungry and needy people.

Foremost on the agenda for the evening's business were the plans for the 11th annual all-day conference to be held at the Beverly Hilton Hotel on October 17th. "Food Engineering" is to be the phase of food technology to be emphasized in this year's conference. The luncheon speaker will be Milton P. Duffy, chief of the Bureau of State Food and Drug Inspection. His topic will be "Food and Drug Inspection in California".

Food Engineering Conference Papers

"Technological Advances in Fish Canning" by George Courtney of Van Camp Sea Food Co.

"Recent Trends in Mechanization within the Citrus Industry" by Maurice Johnson, Sunkist Growers, Inc.

"Electronic Color Sorting of Foods" by Louis Thayer of Food Machinery & Chem. Co.

"Water Problems in Industry" by Ralph Westcott, Holladay & Wescott.

"Modern Developments in Spray Draying" by D. D. Peebles, Western Condensing Co.

"Fish Flour and Fish Meal by Azeotropic Solvent Processing" by Ezra Levin, VioBin Corporation.

"Heat Exchangers in the Food Industry" by Warren Enochian, Rietz Man. Co.

"The Packaging of Pressurized Products" by R. C. Webster, Ohio Chemical and Surgical Company.

*—Cora Miller*

## W. NEW YORK

To start its fall activities, the Section held its annual meeting at Niagara Falls, Ont., on October 3rd. The meeting was also a joint affair with members of the Toronto Section of the Canadian Institute of Food Technology (CIFT) attending.

First on the program was a plant tour of Bright Brothers Winery and Cannery at Niagara Falls, Ont. The afternoon session was held in the Sheraton Brock Hotel, Niagara Falls, when the following papers were heard:

*The Problems of Agricultural Chemicals and Their Use*, Dr. C. O. Eddy, Food Machinery & Chemical Corp., Niagara Division, Middleport, N. Y.

*Varietal Behavior in Sweet Corn Maturation*, Dr. Donald W. Barton, Vegetable Crops Dept., N. Y. State Agricultural Experiment Station, Geneva, N. Y.

*Handling Sugar the Modern Way*, Representative of Refined Syrups & Sugars, Inc., Vincent Gage.

*Developments in Chromatography*, Dr. John Kagan, Food Chemistry Dept., University of Toronto.

The dinner, held in the Rainbow Salon, was addressed by Dr. R. K. Larmour, Director of Research, Maple Leaf Milling Co., Toronto, Ont. His topic: "World Food Supplies."

## MARYLAND

By self-introduction of all present, Dr. Hall of McCormick and Co., Inc. opened the first fall meeting of the Maryland Section at the Stafford Hotel, in Baltimore, Md., on September 19, 1958. Two talks were presented. Recent advances in the technology and manufacture of enzymes which has led to commercial applications in the baking, brewing, candy, wine, fruit juice, distilling, and cereal industries were described by Dr. Dale Harris of Rohm & Haas Co., Philadelphia, Pa. "The Use of Ion Exchange Resins in the Food Industry" was the subject of an interesting slide-illustrated talk given by Mr. Robert Percival, also of Rohm & Haas Co., Philadelphia, Pa.

*—L. F. Giesecker*

# Literature

## BOOKS

MICROBIOLOGY. Michael J. Pelczar, Jr. and Roger D. Reid. McGraw-Hill Book Co. New York, 1958. 564 pp.

This text introduces the student to the world of microorganisms. About half the book is devoted to fundamentals of microbiology; the remainder is concerned with the practical applications of microbiology in the everyday environments of man.

The subject is presented under the following six headings: (1) a survey of microbial life and historical aspects of microbiology, (2) characteristics of bacteria as prototypes of all microorganisms, (3) characteristics and importance of microorganisms other than bacteria, (4) the control of microorganisms, (5) microorganisms and disease, and (6) other aspects of applied microbiology.

This book is well written. It contains a broad general coverage of the field of microbiology, and is particularly strong on the applied phases. The latest concepts and knowledge in this rapidly growing field are presented. Considerable effort has been made to aid the reader's comprehension with the use of charts, tables, illustrations, and review questions.

In this text there is overemphasis on the presentation of laboratory techniques, many of which will not be used in the laboratory by students taking their first course in microbiology (e.g., replica plating for isolating bacterial mutants, the complement-fixation test, post-mortem examination of small animals, and highly specialized methods for the microbiological analysis of air).

The use of summarized tables for giving differentiating characteristics of species of a genus such as the streptococci is a great aid in clearly presenting much usable information. On the other hand, similarly presented data on genera of *Neisseria*, *Clostridium*, and *Pasteurella* fall somewhat out of the scope of an elementary text.

The detailed descriptions of the ten orders of bacteria in Chapter 12 could probably have been more appropriately placed in the appendix. In fact, the information on orders not likely to be encountered by beginning students does not need to appear in the book at all.

The student for whom this text is intended should have an elementary knowledge of chemistry, physics, and biology. However, even with this background he will likely be more overwhelmed than fascinated by the table showing the anaerobic dissimilation of glucose, or the tables and figures containing the structural formulas for the sulfonamides, penicillins, and tetracyclines.

The opening section, "Introduction to Microbiology," is a very readable elementary discussion orienting the student to the scope of the subject matter, and pointing out milestones in the development of microbiology from modest beginnings to its present status as an important and fascinating science.

The second section, "Characteristics of Bacteria," presents sufficient material for a general course designed for students who plan no additional training in microbiology, but is too brief for a good basic course in which bacteriology usually receives the major emphasis.

In general, the remaining four sections of the book are adequate background for specialized courses embracing any of the topics covered.

The authors state in the preface that, "The instructor should feel no compulsion to follow the sequence used in this book, since the material can be presented with equal effectiveness when it is rearranged to fit his individual preference." Many teachers may prefer to present first all the nonpathogenic subjects, including the several subtopics of applied microbiology, before yielding to the wishes of the average student by presenting the more fascinating pathogenic topics. In this way the interest of the class can probably be more easily maintained until the end of the course.

In conclusion, the authors have taken a wealth of information on a broad group of microbiological subjects, and have presented it in an interestingly written and very readable volume. This book is a particularly fine text for students desiring microbiology as a component of their cultural training.

R. O. WAGENAAR
Minneapolis, Minnesota

THE LIPIDS, THEIR CHEMISTRY AND BIOCHEMISTRY, Vol. III. Biochemistry. Harry J. Deuel, Jr., Interscience Publishers, Inc., New York, 1957, pp. 1065.

Dr. Deuel has utilized the two distinct divisions in lipid biochemistry in preparing two volumes of his three-volume series on *The Lipids*. The closely related phases of fat digestion, absorption, transport and storage were presented in volume II. The second division of the biochemistry of fats, which comprises volume III, is dealt with under the general title "intermediary methabolism" and covers the biosynthesis, oxidation, metabolism and nutritional value of fats.

The text of volume III was completed by Dr. Deuel before his untimely death on April 17, 1956. He had completed most of the necessary writing before his death and it remained for some of his colleagues and friends to see this written material through the press.

The book is divided into 14 chapters. The two largest chapters deal with the oxidation and metabolism of triglycerides, fatty acids, and glycerol in the animal body and the metabolism and nutritional value of the carotenoids and vitamin A. Studies on the metabolism and nutritive value of vitamins D, E, and K are presented in separate chapters. Other chapters consider such topics as, the conversion of fat to carbohydrate; phospholipid studies; acetic, formic and propionic acids in intermediary metabolism; the metabolism of fatty acids other than the normal straight-chain acids; and the physiology and biochemistry of the essential fatty acids. In the last chapter consideration is given to the essential role of fat in the diet by a presentation

of recent knowledge of the nutritional value of fats.

The book contains a total of 4,255 references conveniently placed at the bottom of the page on which the topic is discussed. This aids in the usefulness of the book as a review and reference text, the purpose for which it is specifically intended. For the research student and the research worker on fats, this book is highly recommended as an invaluable and unique source of information. The combined volumes of *The Lipids* serve today as the prime source of information dealing with our present knowledge encompassed in the broad biochemical field of lipids.

ROBERT B. KOCH
Broadview, Illinois

# ABSTRACTS

**—Compiled by H. A. Campbell**

## ANALYTICAL METHODS

**Food analysis—techniques, interpretation and legal aspects.**

PEARSON, D. (Natl. Coll. Food Technol., London, Engl.). *Lab. Practice 7*, 92–4 (1958).

The part the anal. chemist plays in quality control in the food industry is discussed. The various types of samples handled are considered together with some general ideas for reporting on them. The role of statistics is also discussed.

**Automatic recording apparatus for use in the chromatography of amino acids.**

SPACKMAN, D. H., STEIN, W. H. AND MOORE, S. (Rockefeller Inst. for Med. Research, New York City). *Anal. Chem. 30*, 1190–1206 (1958).

Quantitative detn. of amino acids is made simpler and more rapid by an instrument for automatically recording the ninhydrin color value of the effluent from ion exchange columns. A hydrolyzate of a protein or peptide may be analyzed in less than 24 hrs. The more complex mixts. characteristic of blood plasma, urine, and mammalian tissues can be analyzed in 2 days. The instrument is applicable in principle to detection of ninhydrin-positive constituents in the effluent from various types of chromatograph columns.

**Chromatography of amino acids on sulfonated polystyrene resins. An improved system.**

MOORE, S., SPACKMAN, D. H. AND STEIN, W. H. (Rockefeller Inst. for Med. Research, New York City). *Anal. Chem. 30*, 1185–90 (1958).

Improved procedures have been developed for the chromatographic detn. of amino acids on columns of finely pulverized 8% cross-linked sulfonated polystyrene resins. The use of a smaller particle size has permitted faster flow rates, and appropriate choice of eluents has simplified operations. Complete analysis of protein hydrolyzates can be performed in about 48 hrs. with fraction collectors and in 24 hrs. with automatic recording equipment. The same system with minor modifications can be used for the detn. of amino acids and related compds. in blood plasma, urine, and animal tissues.

**A paper chromatographic study of the effect of synthetic digestive fluids on the sodium salts of tri-, tetra-, and hexametaphosphoric acids.**

MITCHELL, L. C. *J. Assoc. Offic. Agr. Chemists 41*, 185–7 (1958).

A solvent system and chromogenic agent are described for paper chromatographic sepn. of inorg. phosphates. Metaphosphates were not hydrolyzed by U.S.P. XV formula for simulated intestinal fluid after 1 week incubation at 37°C.

## BIOLOGICAL SCIENCES

### Biochemistry

**Evaluation of protein quality. I and II.**

FRIEDMAN, L. AND DERSE, P. H. (Wisconsin Alumni Research Foundation, Madison). *J. Assoc. Offic. Agr. Chemists 41*, 188–94 (1958).

A clear cut need for evaluating the supplementary effect of a given protein has become important with the new stress on improvement of protein quality, especially in cereal foods. One standard procedure suggested involves growth of weanling rats on a standard diet as compared to a diet contg. the protein being studied. Ether exts. were made on the livers at the end of the test period.

**Biosynthesis of collagen. III. The direct action of ascorbic acid on hydroxyproline and collagen formation in subcutaneous polyvinyl sponge implants in guinea pigs.**

GOULD, B. S. (Massachusetts Inst. of Technol., Cambridge). *J. Biol. Chem. 232*, 637–49 (1958).

Collagen biosynthesis as measured by hydroxproline synthesis in subcutaneously implanted polyvinyl sponges has been studied in normal, scorbutic, and ascorbic acid-treated guinea pigs. It has been found that hydroxyproline formation in such a system under various conditions is analogous to hydroxyproline formation in granulation tissue. A direct, specific effect for ascorbic acid in collagen biosynthesis *in vivo* has been demonstrated. It appears that rapid collagen biosynthesis such as that involved in tissue repair may be directly mediated by ascorbic acid, in contradistinction to collagen formation in tissue culture which appears to be independent of ascorbic acid, suggesting the possibility of more than a single biosynthetic pathway.

**Plasma ketosteroid in adrenal-tumor bearing mice.**

POORE, W. AND HOLLANDER, V. P. (Cancer Research Lab., Univ. of Virginia Med. School, Charlottesville). *Proc. Soc. Exptl. Biol. Med. 97*, 644–6 (1958).

A transplanted adrenal mouse carcinoma produced elevated plasma ketosteroid in the host. Non-tumor-bearing mice subjected to gonadectomy-adrenalectomy have negligible levels of plasma ketosteroid. Tumor-bearing mice have unchanged plasma levels following this procedure indicating steroid production by the tumor.

### Nutrition

**Measuring human effort.**

BROUHA, L., E. I. du Pont de Nemours & Co., Wilmington, Del.). *Mech. Eng. 80*, 81–3 (June 1958).

When a well-co-ordinated and systematic program is developed, it will be possible to replace the notion of "mechanical work cycle" by the concept of "physiol. work cycle." This will give a more accurate picture of the effort required by the worker and will furnish quant. data for estimating fatigue.

**Evaluating body composition.**

COWGILL, G. R. (Yale Univ., New Haven, Conn.). *Bordens Rev. 19*, 1–17 (1958).

In this article an endeavor has been made to indicate the ideas that have been advanced and the various types of studies that have been carried out in an effort to measure "nutritional status" with particular reference to the question of the amt. of fat in the body. It is quite evident that some promising advances have already been made but that much more work remains to be done on this interesting and important problem.

**Measurement of 'basal' and total metabolism in hereditarily obese-hyperglycemic mice.**

MCCLINTOCK, R. AND LIPSON, N. (Dept. of Physiol., Univ. of Minnesota, Minneapolis). *Am J. Physiol. 195*, 495–8 (1958).

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Measurements of oxygen consumption and $CO_2$ production were made by the Haldane open circuit method on hereditarily obese mice and littermate controls, and the energy expenditures were estd. The total energy expenditures of fed and unconfined obese mice were found to be higher than those of non-obese littermate controls by virtue of increased 'basal metabolism', greater energy expenditure assocd. with feeding, and possibly larger energy output for activity despite reduced voluntary movement.

**On the restoration of fatty acid biosynthesis after fasting.**

CATRAVAS, G. N. AND ANKER, H. S. (Dept. of Biochem., Univ. of Chicago, Ill.). *J. Biol. Chem. 232*, 669–80 (1958).

A factor was found to be present in the liver of normal rats and pigs and in yeast which, when added to a liver homogenate from fasted rats, increased the rate of incorporation of acetate carbon into fatty acids. Up to a 30-fold increase was obtained with material from yeast which had been purified approximately 400-fold and appeared to act in catalytic amts. The concn. of this material in the liver seemed to depend upon the nutritional state of the animal and to control the rate of fatty acid synthesis in this organ.

**Essential fatty acids and idiopathic hypercalcemia of infancy.**

JAMES, A. T., WEBB, J., STAPLETON, T. AND MACDONALD, W. B. (Natl. Inst. for Med. Research, London, Engl.). *Lancet 7019*, 502–4 (1958).

The results presented do not support the proposition that the actual processing of cow's milk, whether by vacuum evaporation or by roller drying, causes any great fall in the level of linoleic + linolenic acids. The level of linoleic + linolenic acids did, however, fall on prolonged storage of dried milks, but there was no evidence at present to suggest that the levels observed lead to any deficiency. The results do not provide any evidence that an essential fatty-acid deficiency is a cause of, or is present in, infants with idiopathic hypercalcemia.

**Essential fatty acids in cell permeability.**

*Nutrition Revs. 16*, 116–17 (1958).

Evidence appears to indicate that the function of oleic acid and the other growth promoting fatty acids and surface active agents is in promoting the passage of certain substances, such as biotin, across the cell membrane.

**Plasma unesterified fatty acids.**

*Nutrition Revs. 16*, 102–4 (1958).

The unesterified fatty acids in plasma are extraordinarily sensitive to administration of glucose, insulin, epinephrine and other determinants of carbohydrate utilization, and insensitive to fat digestion. They have a half-time of only a few minutes. In the fasting state they are extd. by a variety of tissues, but are put into circulation by adipose tissue. Both extn. and release are promptly stopped by administration of insulin and glucose.

**Mechanism of cholesterol absorption. II. Changes in free and esterified cholesterol pools of mucosa after feeding cholesterol-4-C$^{14}$.**

SWELL, L., TROUT, E. C., HOPPER, J. R., FIELD, H. et al. *J. Biol. Chem. 233*, 49–53 (1958).

The present study has provided evidence that a metabolic pool of free cholesterol exists in the intestinal mucosa. The existence and turnover of this pool has made it possible to explain certain aspects of cholesterol absorption and also to postulate a mechanism of absorption.

**Cholesterol as a carcinogen.**

HIEGER, I. (Roy. Cancer Hosp., London, Engl.). *Proc. Roy. Soc. (London) B147*, 84–9 (1957); *Chem. Abstr. 52*, 9417 g (1958).

Highly purified cholesterol is carcinogenic. Its soln. in olive oil (prepd. at temp. of the water bath) was injected subcutaneously into 224 stock mice; sarcoma developed at the site of injection in 14 animals.

**The effect of nicotinic acid upon serum cholesterol and upon basal metabolic rate of young normal adults.**

ALTSCHUL, R. AND HOFFER, A. (Lab. of Gerontol., Univ. of Saskatchewan, Can.). *Arch. Biochem. Biophys. 73*, 420–4 (1958).

Nicotinic acid in relatively large doses (3 × 1 g. daily) lowered the serum cholesterol in 11 out of 12 healthy medical students. The basal metabolic rates increased slightly but significantly. It seems that the relative response of cholesterol levels to nicotinic acid is related to the dosage in terms of wt. The response may depend upon the initial cholesterol levels.

**The biological activities of ε- and ζ-tocopherols.**

WARD, R. J. (Univ. of Cambridge, Engl.). *Brit. J. Nutrition 12*, 226–31 (1958).

Natural ε-tocopherol (5-monomethyl tocol), isolated from wheat-bran oil and synthetic δ-tocopherol (5:7-dimethyl tocol) were given to groups of 2 male and 2 female rats in graded doses. ε-Tocopherol was found to have less than 7.5% of the activity of α-tocopherol. δ-tocopherol had about 40% of the activity of α-tocopherol.

**Dietary sodium in essential hypertension.**

DAHL, L. K. (Med. Dept., Brookhaven Natl. Lab., Upton, N.Y.). *J. Am. Dietetic Assoc. 34*, 585–90 (1958).

Current average levels of salt ingestion in most modern societies appear to be well beyond physiologic need and probably represent an induced appetite, much like those of smoking and drinking alcohol. Among groups and individuals in which a low-salt diet is eaten, essential hypertension is uncommon; by contrast, where a high-salt diet is common, hypertension and its complications are frequent.

**Dietary calcium and radiostrontium retention.**

*Nutrition Revs. 16*, 153–4 (1958).

Studies conducted with rats have clearly demonstrated that increasing the dietary calcium intake will reduce the assimilation of radiostrontium. Short term studies indicate that feeding a diet of 2.0% calcium allows rats to retain only one third as much radiostrontium as diets contg. 0.5% calcium. Longer term studies showed rats fed 2.0% calcium only retained 3.8% of the ingested radio-strontium while those fed 0.5% calcium retained 17.7%.

**The oral treatment of pernicious anemia.**

HEATHCOTE, J. G. AND MOONEY, F. S. *Lancet 7028*, 982–7 (1958).

A new hypothesis is put forward that the orally active form of vitamin $B_{12}$ is a peptide complex. Such a vitamin-$B_{12}$-peptide has been isolated from a fermentation of streptomyces, and it has been shown clinically to be the most effective oral prepn. yet available. It is postulated that this active complex could be produced in the stomach by simple proteolysis, and that the intrinsic factor probably does not exist.

**Electrolyte imbalance in vitamin $B_6$ deficient rats.**

HSU, J. M., DAVIS, R. L. AND CHOW, B. F. (Dept. of Biochem., School of Hygiene and Public Health, Johns Hopkins Univ., Baltimore, Md.). *J. Biol. Chem. 230*, 889–95 (1958).

Adequate intake of vitamin $B_6$ is essential for the maintenance of Na and K balance in rats inasmuch as dietary deprivation of the vitamin results in an elevation of the serum Na level. Vitamin $B_6$ deficiency produced an increase in K and a decrease in Na levels of muscle incoordination.

**Vitamin E and selenium, part I.**

*Nutrition Revs. 16*, 149–52 (1958).

Evidence provided by several investigators indicates selenium is an essential trace element believed to take part in

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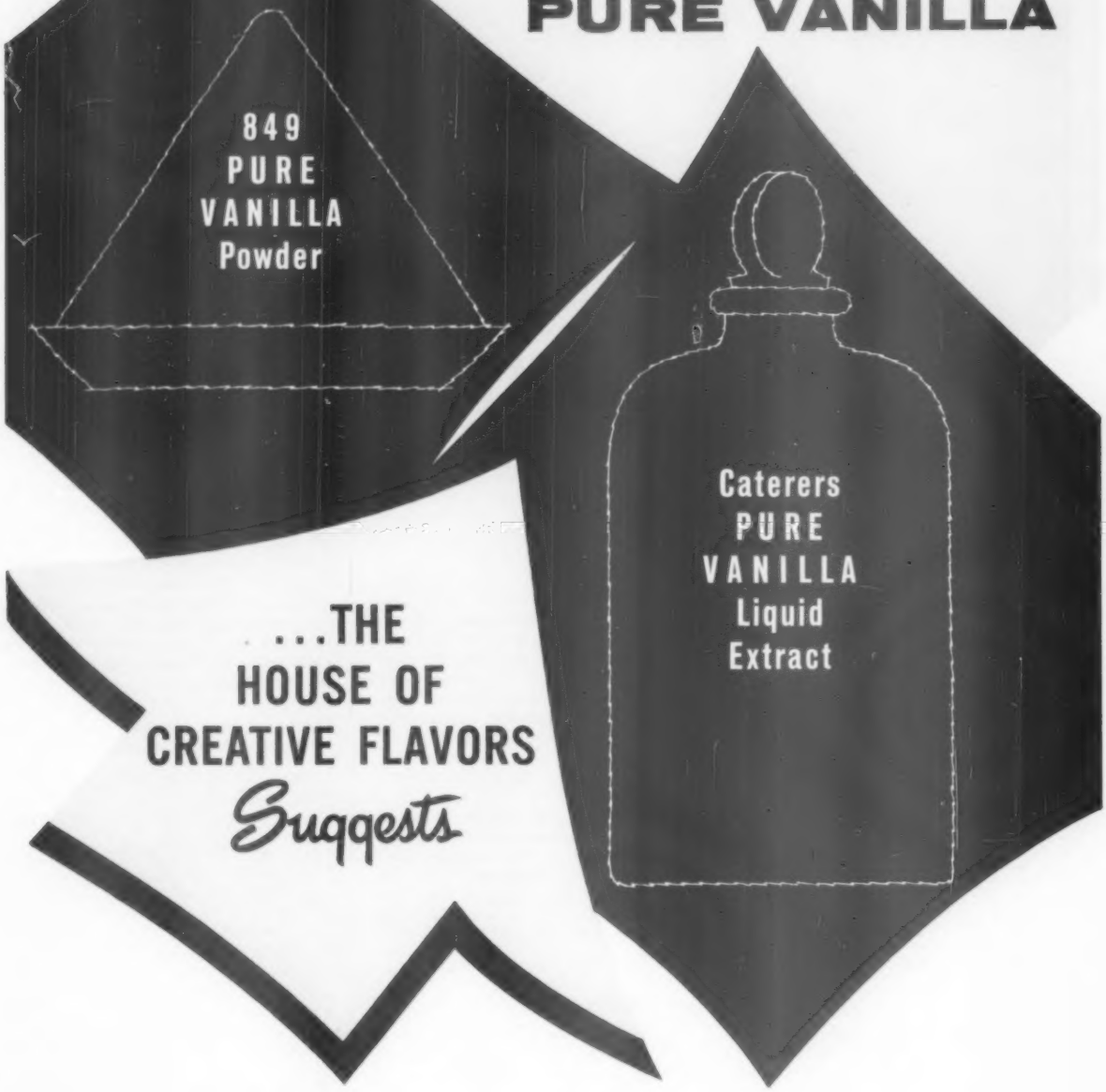


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oxidation-reduction reactions. Evidence has also been provided that selenium can replace vitamin E for the prevention of exudative diathesis in chicks and necrotic liver degeneration in rats.

**Flour and bread, prepared with or without treatment with chlorine dioxide, as long-term sources of vitamin E for rats.**

MOORE, T., SHARMAN, I. M. AND WARD, R. J. (Univ. of Cambridge, Engl.). *Brit. J. Nutrition 12*, 215–25 (1958).

Rats were fed for 15 to 17 months on diets composed mainly of flour or on bread baked from this flour. No evidence of vitamin E deficiency was found in either expt., provided that the flour had not been subjected to chem. treatment. Flour treated with chlorine dioxide, at about the usual com. level, or bread baked from it, was ineffective as a source of vitamin E. The lesions developed were typical of avitaminosis E.

**Nutrition, life tenure, and the degenerative diseases.**

GOODMAN, J. I. (Mt. Sinai Hosp., Cleveland, Ohio). *Geriatrics 13*, 359–66 (1958).

Obesity plays a large part in the disabilities of later life. It appears to be significant in the increasing incidence of diabetes, gangrene, congestive heart failure, and cerebrovascular accidents. There are numerous instances of suboptimal nutrition in all economic classes. Malnourished elderly individuals become this way for the same reason that cause deficiencies in younger people, namely, poor diet selection.

**Short-term rat feeding studies with gamma-irradiated food products.**

READ, M. S. AND KRAYBILL, H. F. (U.S. Army Med. Nutr. Lab., Denver, Colo.). *J. Nutrition 65*, 39–51 (1958).

Fourteen foods irradiated with 3 or 6 million rep and subsequently stored in the frozen state have been fed *ad libitum* to rats for 8 to 12 weeks as 35% of the dry wt. of the diet. The remaining 65% of the diet was non-irradiated nutritionally adequate semi-synthetic ration. Thirteen foods (bacon, snap beans, beef, beets, bread, cereal bar, corn, haddock, fresh ham, powdered milk, spinach, strawberries and turkey) have been found to be non-toxic by this technique. The interpretation of these results has been discussed.

**Role of glutamine in tissue culture.**

*Nutrition Revs. 16*, 157–8 (1958).

Although glutamine is not a dietary essentinl for higher species because of the ability of certain organs to synthesize it in adeqate quantities it appears that glutamine must be included among the non-essential amino acids that must be synthesized in the animal body from non-specific nitrogen sources.

**Effect of galactose ingestion on the urinary amino acid excretion in the rat.**

HUMAN, L. E., MIDDLETON, M. AND GEIGER, E. (Univ. of Southern California Med. School, Los Angeles). *Am. J. Physiol. 193*, 69–72 (1958).

Groups of weanling rats were fed diets contg. various levels of galactose or glucose or both. The excretion of amino acids was not affected by the type or quantity of ingested carbohydrate. It seems likely, therefore, that the aminoaciduria observed in galactosemic infants must be due to some cause other than the toxic effects of galactose itself or a competition for the renal reabsorption mechanism.

### Toxicology

**Poisonous fishes.**

HALSTEAD, B. W. (School of Tropical and Preventive Med., Coll. of Med. Evangelists, Loma Linda, Calif.). *Public Health Rep. 73*, 302–12 (1958).

Fishes are believed to become poisonous as a result of their food habits—feeding on marine algae. Poisonous fishes cannot be detected by their appearance. Fish poisoning should not be confused with bacterial food poisoning, with which it has no etiological connections. With the exceptions of gempylid diarrhea and scombroid poisoning, all other types of ichthyosarcotoxism are characterized by neurotoxic symptoms. The treatment of fish poisoning is symptomatic. Little is known about the chem. and pharmacol. properties of fish poisons.

**Binding of gossypol under conditions of complete rupture of the pigment glands.**

KING, W. H., FRAMPTON, V. L. AND ALTSCHUL, A. M. (Southern Regional Research Lab., New Orleans, La.). *J. Am. Oil Chemists' Soc. 35*, 358–60 (1958).

The "free" gossypol of cooked cottonseed meats is composed of gossypol and of "gossypol-like pigments," which are sol. in 70% aq. acetone. The "gossypol-like pigments" may account for 30-100% of the "free" gossypol as detd. by the A.O.C.S. method. Thorough comminution, followed by prolonged cooking, results in reduction of all the pigments in cottonseed meats. "Free" gossypol is not completely eliminated, but the gossypol level, as detd. by the benzene transfer method, may be reduced to zero.

## DETERGENTS

**Glossary of terms used in detergent industry—in German, French and English.**

CARRIERE, G. (Lab. Lever's Zeep-Mij. N.V., Vlaardingen, Holland). *Fette, Seifen Anstrichmittel 60*, 381–8 (1958).

This glossary lists each term in English with its French and German equivalent.

## ENGINEERING RESEARCH

**Effects of drying conditions on the properties of spray-dried particles.**

CROSBY, E. J. AND MARSHALL, W. R. (Univ. of Wisconsin, Madison). *Chem. Eng. Progr. 54*, 56–63 (July 1958).

A study relating the size and density of spray-dried particles to the initial spray drop size, with convential operating variables as parameters.

## FOOD AND FOOD TECHNOLOGY

### Additives

**Composition of polyoxyethylene (8) stearate.**

BIRKMEIER, R. L. AND BRANDNER, J. P. (Atlas Powder Co., Wilmington, Del.). *J. Agr. Food Chem. 6*, 471–5 (1958).

The composition of polyoxyethylene (8) stearate was investigated to det. its safety as a food additive. This compd. contains unesterified polyoxyethylene glycol and polyoxyethylene glycol monostearate, distearate in the molar proportions of 1.1 to 2.0 to 1.0, with free and esterified polyethylene glycols having equal lengths. After allowance for small amts. of catalyst and water, the results are those expected if rapid ester interchange occurs. The polyglycols through the nonamer comprise 81% of the total polyglycols and the polymer distribution approximates a Poisson distribution.

### Cereals and Grains

**Nutritive value studies of wheat flakes, dried whole milk and sugar mixture.**

REUSSNER, G. H. AND THIESSEN, R. (Research Center, General Foods Corp., Tarrytown, N.Y.). *Food Research 23*, 244–53 (1958).

Diets contg. wheat flakes, whole dry milk solids and sugar, whole milk solids and bacon, eggs, toast, and coffee were fed to growing rats. At the end of 9 months some of the animals fed the bacon and egg diet had large, fatty livers and those consuming the milk alone had low blood protein and hemoglobin values. Rats consuming the wheat flakes, milk and sugar mixt. did not show such abnormalities. The wheat flakes, milk solids, and sugar diet and the bacon and egg diet both gave good growth and survival to rats on long-term feed.

**The inhibition of beta-amylase by ascorbic acid.**

ROWE, A. W. AND WEIL, C. E. (Rutgers Univ., New Brunswick, N.J.). *Cereal Chem. 35*, 289–94 (1958).

The inhibition of β-amylase by ascorbic acid has been found to be noncompetitive. This contrasts with the competitive type of inhibition caused by parachloromercuribenzoate. The nature of this inhibition and its acting by some mechanism other than a direct reaction with the essential sulfhydryl groups of the enzyme are discussed.

### Cocoa and Cocoa Products

**The causes of fat bloom in coated and solid chocolates.**

BECKER, K. (Chocolate lab., Inst. for Food Technol. and Packaging). *Intern. Chocolate Rev. 13*, 254–6 (1958).

It is postulated that fat bloom is due to the sepn. of mixed glyceride crystals rather than to polymorphic changes. Phase diagrams showing metastable areas are given, and possible methods of preventing bloom, based on this theory, are presented.

**A new rheological relationship to express the flow properties of melted chocolate.**

STEINER, E. H. (Brit. Manuf. Ind. Research Assoc.). *Intern. Choc. Rev. 13*, 290–5 (1958).

A new equation of flow is proposed in which a linear relation exists between square root of stress and square root of rate of shear. These quantities should permit an evaluation of 2 consts. (intercept and slope) which will characterize the whole flow curve of chocolate.

**The rapid artificial drying of cocoa beans and chocolate flavour.**

POWELL, B. D. (Cadbury Brothers, Ltd., Engl.). *Tropical Agr. 35*, 200–4 (1958).

The fruity flavor which is found in artificially dried cocoa beans is shown to be due to the presence of an excess of acetic acid. Adequate conching will remove this unwanted flavor.

### Coffee

**Sampling method for analysis of coffee volatiles by gas chromatography.**

RHOADES, J. W. (Southwest Research Inst., San Antonio, Texas). *Food Research 23*, 254–61 (1958).

A sampling procedure has been developed for the comparative analysis of the volatiles from ground roasted coffee by the use of gas chromatography. Chromatograms exhibiting some 16 distinct peaks were obtained. Variation of peak areas with different coffee samples are distinctive and reproducible. Data have been included which show differences between coffee samples. These differences are far in excess of the apparent exptl. error.

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### Confections

**Method of making a frozen confection.**

SHARPLES, A. E. *U. S. 2,843,493.* July 15, 1958.

Method of making a frozen food having a soft core and a hard frozen skin. A charge of frozen shavings is placed in a mold and heated until the surface is liquefied. Deep freezing of the mold transforms the liquefied surface into a hard frozen skin.

### Fruit

**Enzymic hydrolysis of naringin in grapefruit.**

TING, S. V. (Univ. of Florida Citrus Expt. Sta., Lake Alfred). *J. Agr. Food Chem. 6,* 546–9 (1958).

Naringin, a bitter principle of grapefruit and shaddock, was found to be hydrolyzable by an enzyme occurring in a com. pectinase. The hydrolytic activity of the enzyme was most effective at 50° C. and pH 4. Varying the citrate ion concns. had no effect on the enzyme activity, but the hydrolytic end products decreased the rate of hydrolysis. The hydrolysis of naringin from the various parts of grapefruit was studied. Applications of the enzymic hydrolysis for "debittering" various grapefruit products were suggested as well as the use of this enzyme in connection with a more specific colorimetric detn. of naringin in grapefruit products with NaOH.

### Gelatin and Gums

**The charge and deformation of protein molecules.**

PASYNSKII, A. G. (Academy of Sci. of the U.S.S.R., Moscow). *J. Polymer Sci. 29,* 61–8 (1958).

The density of like-charged groups distributed along the molecules of proteins is much lower than in molecules of polyelectrolytes. From this it follows that the degree of deformation of the protein molecules resulting from the charge is much less. In buffered solns. the shape of gelatin particles practically does not depend on the pH, while in unbuffered solns. it varies roughly in proportion to the fourth to fifth root of the number of charges. For molecules of serum albumin and egg albumin the deformation is proportional to the 25th to 30th root of the number of charges, i.e., completely negligible. This comparison also shows that the deformation of the threadlike molecules of gelatin occurs much more easily than with the firm molecules of the globular proteins.

**The digestibility of polysaccharides by rats.**

CAREY, P. L. (Purdue Univ., Lafayette, Ind.). *Dissertation Abstr. 18, 1962* (1958).

Purified cellulose, xylan, alfalfa seed gum, corn fiber gum, hemicellulose-B,

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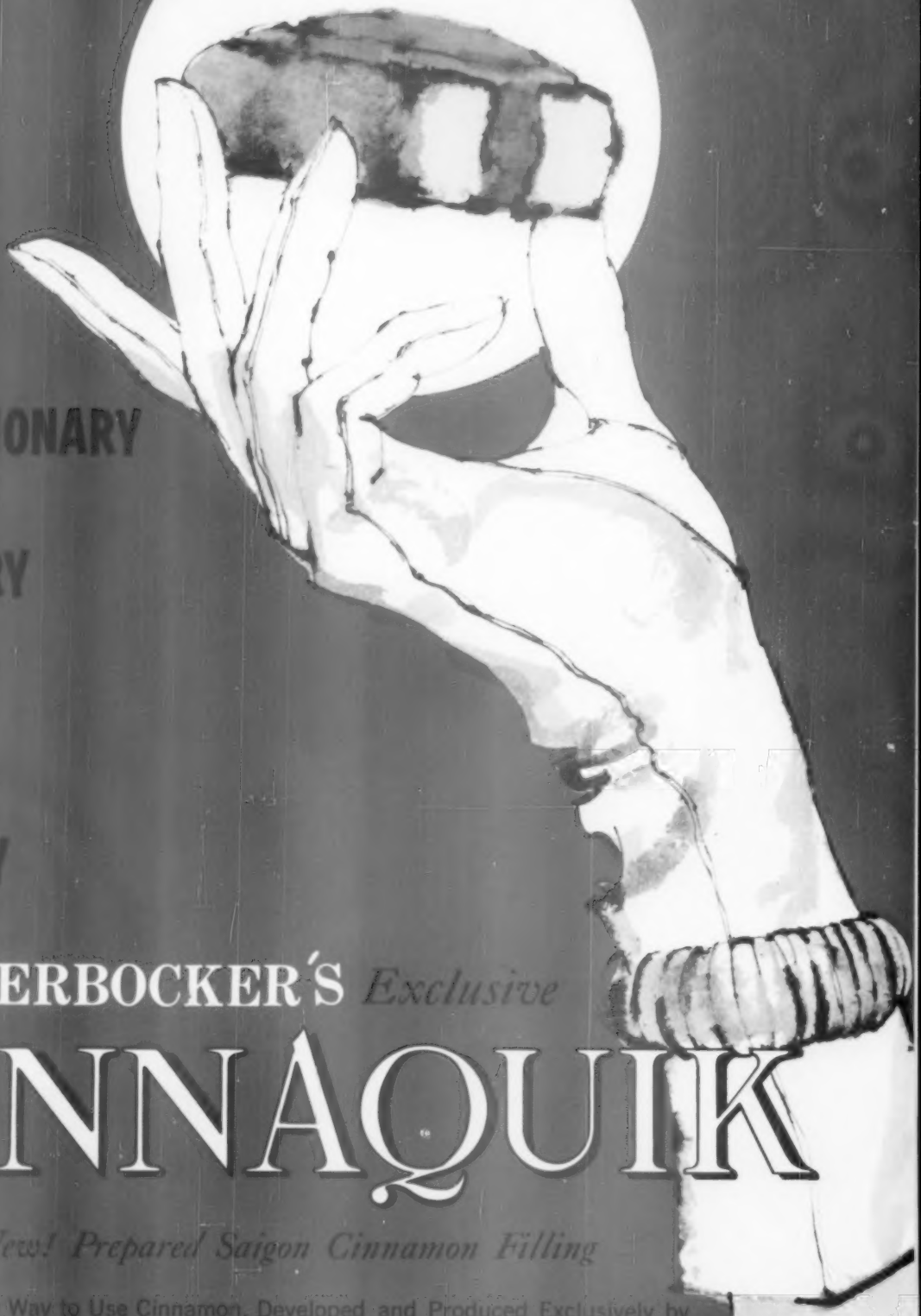

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pectin, algin, carrageenin and dextrin-S were fed in balanced diets to rats and their digestibility and utilization measured. Growth was retarded by all diets except those of cellulose and xylan; however, the adverse effects of growth and food utilization are of no significance when considered on the basis of the low consumption in dietary formulation.

### Milk and Milk Products

**Dispersibility of foam-dried fat-containing milk products.**

ESKEW, R. K., ACETO, N. C., SINNAMON, H. I. AND SCHOPPET, E. F. (Eastern Regional Research Lab., Philadelphia, Penna.). *J. Dairy Sci., 41*, 753–60 (1958).

Whole milk foam-dried has superior dispersibility than when dried conventionally. It can be stored for at least one year at 73°F. without losing dispersibility but some loss occurred at 100°F. This process was successfully applied to a lactose enriched whole milk, and modified whole milk and a chocolate-flavored whole milk.

### Pectin

**Metabolism of methionine and pectin esterification in plant tissue.**

SATO, C. S., BYERRUM, R. W., ALBERSHEIM, P. AND BONNER, J. (Kerckhoff Labs. of Biol., California Inst. of Technol., Pasadena). *J. Biol. Chem. 233*, 128–31 (1958).

S-methylmethionine acts as a methyl donor in the formation of pectin and protopectin. It is, however, less effective in this function than either methionine or methionine sulfoxide. Sulfur-labeled methionine and methionine sulfoxide were shown to be incorporated into the pectin and protopectin fractions.

### Taste Testing

**Who eats what, when—and why.**

ANON. *Tide 32*, 29–30 (June 13, 1958).

Market Research Corp. of America, hired by Campbell Soup, General Foods, General Mills and Pillsbury Mills to conduct a study of U.S. eating habits, employed the use of a complex electronic gadget (IBM 704) for their survey. This machine has the ability to tabulate and store an infinite number of questions and answers pertaining to current eating habits. A brief summary is given of some of the results as well as cost figures of the survey.

**Fashions in food.**

ADOLPH, W. H. *Harper's 216*, 57–61 (June 1958).

Trends in likes and dislikes for various foods by people in different ems and different countries are reviewed. The reasons, if any, for these trends, from cannibalism to sipping tea, are discussed.

### Miscellaneous

**Lone invention no lost art.**

LINCOLN, J. W. *Product Eng. 29*, 26–7 (June 2, 1958).

The present article is in answer to a paper written by Dr. William J. Kroll in the Feb. 24, 1958 issue of Product Eng. in which he states that industry is discouraging the creative spark in individuals by using the process of collective invention. Mr. Lincoln, however, defends this policy and describes a working and practical method of combining the needs of industry with those of the individual.

## PACKAGING

**A close look at polystyrene film.**

MCCORMICK, R. J. (Dow Chem. Co., Midland, Mich.). *Package Eng. 3*, 23–37 (July 1958).

The second half of a 2-part article, covering the properties, costs, and applications of oriented polystyrene. Physical properties tables include gas and vapor permeability in comparison to other films. Prices which include yield factors in several gauges, are also compared with other films. Heat sealing polystyrene is a difficult problem not yet satisfactorily solved. Ink adhesion and printing in general on polystyrene film are good. Food packaging applications include: windows in cartons, bacon overwraps, which do not distort nor wrinkle in humidity changes, exposure to bacon fat, or fog; and fresh produce wrapping, where moisture transfer and oxygen "breathing" are necessary or not undesirable. 23 references.

**Will waxes meet the production challenge?**

BLOCH, M. (Warwick Wax Co.). *Chem. Week 83*, 49–57 (July 19, 1958).

Statistics show that the packaging demand for petroleum waxes, especially by producers of waxed paper and various food containers, will soon far exceed the supply if the conventional petroleum refining methods are not improved. The conventional methods of producing paraffins and microwaxes are briefly described and some possible improvements are suggested.

**Mold-free cork liners.**

BRIDGES, D. W. (Corn Products Sales Co., New York City). *Modern Packaging 31*, 155–8 (July 1958).

A report on the use of zein (corn protein) as a binder in compn. cork for bottle caps and crowns to resist mold growth. The binder is reported to be nontoxic and imports no unpleasant odor or taste.

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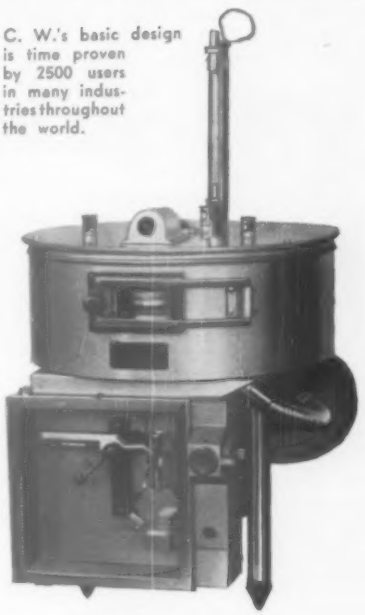

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# Industry

## PERSONNEL

The Research and Development Associates, Food and Container Institute for the Armed Forces, Hdq., 1819 W. Pershing Road, Chicago 9, have established the Rohland A. Isker Award in order to recognize outstanding contributions to military food and packaging progress. Recipients will be selected from (1) civilian or Military personnel of the QM Food and Container Institute for the Armed Forces, (2) personnel of other Armed Services' laboratories and Federal Government agencies cooperating with the Institute in improving rations and packaging. Achievements in basic research, applied research, developmental endeavor or process improvement will be honored. The R and D Associates, as they have come to be called during their long career of public service, are comprised of industry and institutional research people who are devoted to keeping the food and container industries alert to the food and packaging problems of the Armed Forces. The R and D Associates extend the research and development resources of the Government by no-cost counsel on and participation in the solution of problems which industry facilities and personnel are well suited to handle. Membership is open to all industrial organizations, regardless of size, which are concerned with national preparedness in two crucially important areas, foods and packaging.

R. A. Isker

The award, a handsome plaque which will commemorate the recipients' accomplishment, has been named in honor of Colonel Rohland A. Isker, ret'd, wartime Commandant of the Quartermaster Subsistence Research and Development Laboratory (now the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois). Colonel Isker, widely known in the food and packaging industries, distinguished himself prior to and during World War II by building and directing a staff of military and civilian specialists in ration and packaging problems. This organization, out of which grew the Quartermaster Food and Container Institute for the Armed Forces, proved fully equal to the enormous responsibilities which devolved upon it with the advent of World War II.

The first Rohland A. Isker Award will be conferred in the spring of 1959.

H. C. Diehl

**H. C. Diehl,** pioneer in frozen food research, who has been director and secretary of The Refrigeration Research Foundation of Colorado Springs, Colorado, for 15 years, has retired from the foundation, of which he was the organizer and first director. On October 1st, he became managing director of Trans-American Refrigerated Services, Ltd.

**Dr. Roy E. Morse,** professor of of food science, has been named chairman of the Department of Food Science of the N. J. Agricultural Experiment Station, Rutgers University. He succeeds Dr. Walter A. Maclinn, who resigned recently to become executive director of the Refrigeration Research Foundation, Colorado Springs. "As research director for Kingan and Company, meat packers at Indianapolis, Ind., and

R. E. Morse

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for the Wm. J. Stange Company of Chicago, Ill., Dr. Morse produced an important process for electrostatic smoking of bacon and for flash rendering of animal fats," Dr. William H. Martin, director of the station, remarked in making the announcement. "Since joining the State University staff in 1955, Dr. Morse has played a vital role in our research and graduate instruction programs in food science," he added.

A native of Boston, Morse graduated in bacteriology at the University of Massachusetts in 1940. He received his master's degree from the same institution in 1941 and his doctor's degree from Oregon State College and Massachusetts in 1948.

C. C. Slater

**Charles C. Slater** has joined the senior staff of the Midwest Division of Arthur D. Little, Inc., in Chicago, one of the oldest and largest industrial research consulting firms. Dr. Slater's work will be in research on marketing and economic problems, a part of the company's services to business and industry. Dr. Slater, an economist, and author of **Baking in America,** comes to A. D. Little, Inc., from Omar, Inc. where he was vice president and director of marketing of the Omar subsidiary, Supermarket Foods, Inc., in Chicago.

Polak & Schwarz, Inc. announces the appointment of **Joseph A. Ungerland** as Vice President. Mr. Ungerland has been with his present organization for the past eighteen years and has been active in the food flavor field since 1933.

J. A. Ungerland

## PRODUCTS

On September 17, at the Ambassador East, Chicago, at the cocktail hour, *Dariworld cheese*, a recent development by the Department of Dairy and Food Industries of the University of Wisconsin, was announced as the nation's newest cheese product. Dariworld is completely different in character from any other natural cheese ever discovered. First of all, it has the unusual characteristic of reaching the good eating level in a period of 10 days to 2 weeks. Second, after reaching this level, it maintains a uniform flavor indefinitely. It is being distributed by Sue Ann Food Products, Chicago.

Dariworld, a mildly flavored, smooth-textured, creamy cheese, with a refreshing, clean taste in its own right, is also an excellent base for processed cheese spreads. Dariworld was discovered by Professor W. V. Price and Dr. Donald Irvine of the University of Wisconsin while they were working on the further mechanization of the process for making cheddar. The invention has been assigned to the Wisconsin Alumni Research Foundation, world-renowned research organization in Madison, Wisconsin, with an enviable record for producing money for research at the University—total grants to date, $19,000,000.

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